STATE OF NEW YORK

DEPARTMENT OF CONSERVATION

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DIVISION OF WATER POWER AND CONTROL

WATER POWER AND CONTROL COMMISSION

# Report

ON THE

# Geology and Hydrology

OF

# Kings and Queens Counties
# Long Island

J. HOMER SANFORD

Consultant in Geology



BULLETIN GW-7

Albany

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## PREFACE

This geologic report is published as a supplement to Bulletin GW-2, Engineering Report on the Water Supplies of Long Island, prepared in compliance with the provisions of Chapter 839 of the Laws of 1936, as amended. The data in the present report were used in the preparation of the earlier report.

Contour maps of the rock surface under Long Island, of the topography of Sound River valley and of the upper surface of the Gardiners clay, described in this report, are contained in Bulletin GW-2.

It is contemplated that an additional bulletin will be prepared consisting of more elaborate geologic maps of the formations under these counties and also geologic sections.

WATER POWER AND CONTROL COMMISSION

Albany, N. Y.
January 3, 1938

## WATER POWER AND CONTROL COMMISSION

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# I

## PREVIOUS INVESTIGATIONS AND SCOPE OF THIS REPORT

Whatever other reason may be given for limited knowledge about underground water in Long Island, it certainly cannot be laid to indifference. A chronicle of the studies made in previous years of underground features affecting its water resources is almost epic. Long before the Burr-Hering-Freeman Commission made a comprehensive report in 1903, investigations into the enigma of the Island's underground water were recorded.

Primarily, this particular investigation is an endeavor to classify geologic structure underlying Kings and Queens Counties in such manner as to delineate whatever continuity may exist between the various water-bearing formations, together with what effect intervening clay strata may have upon the percolation and transfusion of water between them. Several distinct water horizons are known to exist. It is important to determine how continuous and extensive the intervening clay beds may be, and whether underground conditions favor free percolation of fresh water from upper strata to replenish withdrawal of water from the underlying ones. Likewise, it is essential to determine whether impermeable strata exist in the vicinity of the shore lines, which, either partially or completely, seal the adjacent or underlying fresh water formations against contamination from salt water.

From a practical standpoint, the genesis of Long Island's water study was the report of New York City's Commission on Additional Water Supply, in 1903. Following this, geologic reports by Veatch and Fuller presented the first comprehensive analyses of the character, stratigraphy and manner of deposition of formations overlying bed rock, in the Island's area. Some years later, Crosby made a detailed study for the City of New York, but this was never published in the form of a final report because of his death. There is considerable variance in the views of these geologists as to the period when certain formations were deposited.

To the layman, it may seem of little importance whether water-bearing formations (aquifers) were laid down millions of years ago in what geologists term Tertiary time, or comparatively recently, when Quaternary time was initiated by the advent of the Great Ice Age. However, if we are to find answers to practical queries arising from contradictory well log data, a rationalized conception of the Island's structure is essential as a working basis. The divergent opinions expressed in these geologic studies cover formations of high water-bearing value in a zone between an ancient buried land surface, and the surficial deposits which are undisputedly glacial. Therefore, it is necessary to clarify disputed facts about such an economically important zone.

The old buried land surface represents the top of an ancient coastal plain formed by many millions of years of sedimentary deposition under the sea during Cretaceous time. There is little disagreement among geologists over sediments underlying this Cretaceous land surface. They were deposited directly upon bed rock, which evidently had been subjected to the "planing" effect of pounding ocean waters for many ages, prior to Cretaceous time. The sloping surface of the bed rock is termed the Jurassic peneplain, because its rock gradient was created during a long interval which extended through the Jurassic age.

For better public understanding, it seems sufficient to state that the oldest formations overlying bed rock in Long Island (and in a general way, the thickest) were deposited through many millions of years of continuous sinking of the Atlantic coast. Land streams reaching the shore, then as now, carried their sediments into the sea and spread them over the ocean bed in the form of widespread layers of alternating clays, sands and gravels. This subaqueous deposition was subjected to certain modifications and interruptions because the axis of coastal depression oscillated both landward and seaward. That is, in the vicinity of the shore, the regularity of sedimentation was repeatedly interrupted as the axial line shifted to variable landward or seaward positions during millions of years of deposition over a generally sinking coast. This condition of oscillating axis accounts for the irregular overlapping and interrupted stratification so noticeable in Cretaceous formations above the basal Lloyds gravel.

The Lloyds itself appears to be practically unbroken, although it varies decidedly in thickness. In some places it divides into two members, with an intervening "parting" of clay. Apparently, it is a barrier beach type of formation that moved landward as a widespread and almost continuous sheet during the early part of Cretaceous deposition. Subsequently, it was overspread by clays and fine sands that carried into deeper ocean water from land drainage streams. The fact that the Lloyds in places consists of two members does not argue against its barrier beach origin, as intervening partings, where noted, may simply be lagoon deposits behind a succeeding landward moving line of the barrier beach.

Although the Lloyds constitutes by far the most important aquifer in the Cretaceous sediments, another aquifer is frequently found above it, which is termed hereafter the "Magothy Sand." This upper water-bearing structure is irregular, or possibly lenticular, in character. It is separated from the Lloyds by intervening clay beds of such distinctive character and color as to require its being considered a separate formation, even though it possesses certain barrier beach characteristics. The Magothy Sand has been penetrated by a number of wells in Queens, and erroneously designated as "Lloyds" by drillers. Because of its shallower depth, this has created the false conception of an extremely variable Lloyds horizon. A better method for establishing the position of Lloyds is by its relation to bed rock and the frequent occurrence of a "pink" or mottled clay above it.

The long uninterrupted Cretaceous deposition probably continued without a break through early Tertiary time, including what geologists term the Eocene period. It may have continued into Middle Tertiary but ended when coastal sinking stopped, and the flat peneplain, comprising the ocean floor, was re-elevated above sea level, exposing it to erosion. Evidently, a goodly thickness was removed from the top of this elevated plain as land drainage cut valleys and leveled off the intervening hills, creating typical surface irregularities, commonly found in all sedimentary coastal areas. It is not certain just when the land uplift occurred, but evidences of this ancient surface, encountered in borings, indicate that practically all Tertiary deposition, together with some upper Cretaceous sediments, were removed. Therefore, the ancient land surface is assumed to be generally of Cretaceous material. For this reason, it is termed herein the "Cretaceous land surface."

Veatch and Fuller found very little evidence of Tertiary sediments, except a thin bed of Miocene "fluffy" sand, in the higher hills of the Island. They also predicate deposition of thick gravels (Mannetto) during Lafayette submergence of the Pliocene, subsequently removed by a long period of Post-Lafayette erosion in the closing phases of Tertiary time. In general, they believe Tertiary was largely a period of exposure and erosion of the Island's surface, leaving the above mentioned Cretaceous land surface as a residuum directly upon which sediments of Pleistocene glacial origin were deposited.

Crosby presents a picture that decidedly parts company from these views. He ascribes three periods of land elevation and depression which resulted in secondary deposition above the old surface as a result of base leveling (*) and associated peneplaination.

First, he conceived a land uplift during Middle Tertiary (Miocene) of possibly 2000 feet, which marked the beginning of rock cutting of the Hudson gorge. At this time, gravels were deposited in valleys over Long Island by fluvial (land stream) action. He concedes that possibly these gravels, (which he termed Bethpage) may have originated from very old glacial sources long before the Pleistocene Continental glaciers. Following this great uplift, came slow subsidence during later Miocene, accompanied by base leveling which deposited a series of dark lignitic and pyritic clays, chocolate clays and sands (Kirkwood) over the Bethpage gravels. Crosby's Bethpage corresponds with Veatch's glacial Jameco deposits, and the overlying dark clays are a part of the formation which Veatch termed Sankaty. In Fuller's report, the clays covering Jameco were called Gardiners, by which name they are commonly known today.

Immediately following Miocene deposition, Crosby pictured his next land elevation of several hundred feet during the closing

* Note: Base leveling is a phenomenon of tearing down previously deposited sediments and redistributing them adjacently by the attrition of water at their bases; for example, when sea waves attack a bank.

(Pliocene) period of Tertiary. This was slow and long continued, being culminated by a long stationary elevation during which there was broad development of coastal erosion extending up into the Hudson, Connecticut and other coastal valleys. As the land lifted, the gorge of the Hudson developed. Also, emerging Miocene sediments were eroded, washed seaward and redeposited. The sandy elements near the shore (derived partly from Miocene, and partly from landward exposures of Cretaceous), together with finer off-shore sediments, he termed collectively the Cohansey. All of these sediments, i.e.—both Kirkwood remnants and Cohansey, constitute a zone of generally fine sediments immediately above the Bethpage, and presumably are components of Veatch's Sankaty deposits. Fuller makes a distinction between the lower clay members as Gardiners, and overlying fine sands and sandy clays which he called Jacob.

During the long period of stationary land elevation at Crosby's Pliocene Base Level, he believed the shore line was far seaward of its present position; and that throughout both the stationary and ensuing subsidence periods, the Base Level developed broadly over the coast. It progressed easily across incoherent coastal formations, reducing the surface to an approximate plain. The subsurface of this plain, then, is evidently residual fine sediments blanketing the Bethpage (Jameco) and those same generally dark colored sediments termed Sankaty-Gardiners-Jacob, by the others.

As the plain sank below tide, with shore lines slowly encroaching landward over it, the grinding forces of waves and tides removed all softer particles, leaving a blanket of indestructible quartz, gravel and sand. This beach type deposit is the Yellow Gravel Series according to Crosby, but ascribed to some form of glacial agency by both Veatch and Fuller. Crosby ends his Tertiary chronology with the Yellow Gravel Series. However, he introduces a third uplift of several hundred feet at the very beginning of Quaternary time, just before Continental glaciation set in. This had no effect on water-bearing structure, but is noteworthy because he apparently employed it to correlate an overlying fossiliferous clay and fine sand with Sankaty Head formations in New England. He terms these "Sankaty," in contradistinction to the deeper, predominantly dark colored sediments that Veatch correlated with Sankaty Head deposits.

It should be noted, then, that Crosby's Pliocene Base Level is largely reworking of peneplaination from his preceding Miocene Base Level, evidently with interlamination of beds from both that is difficult to distinguish stratigraphically. The net residuum of these two base leveling and peneplaination processes is a zone of largely fine sediment resting directly upon the valley-filling gravels. This zone is presumably the same as the overspreading clays and fine sands which Veatch and Fuller believe to be outwash glacial deposition from a remote ice front.

In general, it would appear that the total deposition of sediments through all of Crosby's deposition periods, from Bethpage

to "Sankaty" inclusive, differ little in average characteristics from those of Veatch and Fuller. In fact, subsequent well log data seem to bear out Veatch's conception of predominating glacial features in these sediments, especially at the western end of the Island.

The above is presented purely in the way of a general analysis to correlate opinions expressed by Veatch, Fuller and Crosby, and insofar as feasible to rationalize their divergencies. It is not intended by this report to controvert beliefs expressed in these earlier studies or to present data reflecting upon the accuracy of their observations. It is hoped rather to add subsequently developed information from boring records, and compile the whole into an economic analysis. Obviously, the present condition of Long Island's underground water resources has pressing economic importance and minor scientific urgency. Facts are now available, which if properly assembled, should give a fairly accurate picture of the approximate position, thickness and character of the major aquifers underlying Kings and Queens. The paramount features are their continuity and the freedom of water interchange among them. It is economically vital to develop knowledge about the possibilities of exhaustion of deep-seated water formations by pumping them in excess of the rate at which rainfall, after accumulating into the surficial glacial mantle, is able to percolate downward for replenishment. Finally, it is urgent to form some rational conception of the progress of salt contamination, particularly as to whether formations in the vicinity of the shore lines may afford restrictions against free infiltration of salt water.

This report is intended to be a simplified and rationalized picture of the geologic structure in western Long Island that will present a treatise which studious minded individuals can understand. It is hoped to analyze various formations which make up the Island's underground structure lucidly enough for general comprehension, with minimization of abstruse geologic terms.

# II

## GEOLOGIC HISTORY

The first appearance of land in this part of the Atlantic coast far antedates any existence of land life. Its primordial barren rocks, though subsequently much altered, physically and chemically, still are the basement underlying unconsolidated sediments in southeastern New York and southern Connecticut. Many long geologic ages have since elapsed, leaving no vestiges of their work above Long Island's ancient bed rock. Deep, thick sediments carrying oil, gas, salt and coal deposits lie only a few hundred miles westward of us. Ancient seas came into being and ultimately vanished, leaving evidences of life evolution from the earliest primary marine forms through the spread of life from sea to land and culminating with the development of gigantic reptile life. Yet, nothing exists above our ancient bed rock to show these things.

Only a short distance north of the Island, from New Haven northward into the Connecticut Valley, dark red sandstones and shales yield ample fossil evidence of teeming reptilian life during the era (Triassic) when the largest reptilian monsters existed. It is from erosion of these dark red sedimentary rocks that certain reddish or brownish clays and sands were later deposited among the sediments beneath the old Cretaceous land surface. One of these (hereinafter referred to as a "pink" clay) is extensive enough to afford some value as a marker of the top of the Lloyds.

Now, what happened during this geologic hiatus between bed rock and coastal plain sediments beneath Long Island? Obviously, the barren coast was above the sea, exposed to erosion over intervals estimated to total upwards 150 million years. Even though intermittent coastal submergences may have brought deposition, their effect was ultimately obliterated. However, such extremely long erosion afforded great opportunity for the sea to attack and tear down the rock-bound shores. Irregularities and promontories slowly and effectuately disappeared under the efficient planing of waves and tide, leaving a peneplained rock surface, with gradient pitching generally southeastward from outcrops in Astoria, to depths exceeding 1300 feet under Far Rockaway. Further eastward, under the Suffolk County barrier beaches, rock possibly lies more than 2000 feet below tide. The materials removed from the primordial surface were undoubtedly first deposited littorally, i. e. —in the vicinity of the shores, but through many, many millions of years they were apparently finally transported far seaward of the present shores of Long Island. This may have been accomplished by coastal uplift near the close of Jurassic which moved the shore line far seaward of its present position.

Cretaceous deposition, as previously explained, was a long continued coastal sinking process. Crosby's excellent description of the manner of deposition and processess which formed the Cret-

aceous coastal plain seems to best answer the contradictions and abrupt changes characteristic of its strata. During the early part of Cretaceous, Long Island's area remained above sea level. Thick series of Lower Cretaceous deposits exist further south along the Atlantic coastal plain. These ultimately were blanketed when the northward moving line of coastal submergence reached Long Island in Middle Cretaceous time. Geologists have generally agreed upon the fact that formations immediately above bed rock in Long Island are of Middle Cretaceous age, and correlate with similar formations under New Jersey.

One who would understand the peculiarities of how water accumulates and becomes stored underground in Long Island must have some basic picture of the succession and manner of deposition of its various formations. The Island is entirely surrounded by salt water. Its surface is so sandy that one may well wonder why most of the rainfall is not rapidly lost around the shores, rather than percolated downward into deep-seated formations. Since fresh water is lighter than salt, it would appear logical for deep aquifers to be charged with salt water by inflow from the surrounding ocean. Now, as a matter of fact, much fresh water does pass seaward around the shores. But this evidently is because the Island's deep-seated storage spaces are already filled with fresh water. Incoming percolation, therefore, must either displace underlying water by hydrostatic pressure or diffuse laterally towards the shores through surficial permeable sands and gravels.

Evidence is not lacking of the ability of the Island to retain its fresh water storage against intrusion by surrounding salt waters. In fact, rainfall absorbed into the capacious sponge of the Island's glacial surface seems to find rather free means for downward passage into even the deepest aquifers. Not only does it permeate from higher surficial deposits into the water-bearing strata near bed rock, but apparently there exist widespread means for lateral diffusion of fresh water through far reaching extensions of the various aquifers. Interconnection, both laterally and vertically, among water-bearing formations from highest to lowest, has been quite definitely shown. Proof of far reaching transmission of hydrostatic pressure from the Island's central highland to strata deep under the Cretaceous land surface has repeatedly been demonstrated in wells that reach the Lloyds along either the North or South Shores. These frequently have artesian flows that rise considerably above sea level. It seems, therefore, quite definitely assured that any tendency of salt water to preempt underground storage space is checked by some sort of a sealing phenomenon around the shore lines.

Although we have an Island today, originally there was no Island. It was simply a widespread coastal plain, consisting of clays, sands and gravels laid down by land streams in the form of subaqueous deposition as these reached the ocean. These sediments were deposited in a more or less regular wedge-like order, thinnest near the coast, and thicker as they progressed seaward.

At one time, they continued as a relatively smooth peneplain, directly across Long Island Sound, and "feathered" out over the rising bed rock of southeast New York and Connecticut. Possibly, at the extreme point of coastal sinking, the sediments covered much of the southern part of Connecticut, reaching up the Connecticut Valley to the vicinity of Hartford.

Cretaceous deposition was apparently initiated by very gradual depression of the bed rock peneplain. We find only a thin wedge of heterogeneous fine or clayey sediments immediately above the rock. The submerging coast may have been barren or only thinly manteled with sediments. In any case, beach deposition inshore was accompanied by barrier beaches slightly off shore, which moved landward simultaneously as the shore lines of the encroaching sea advanced. These widespread and nearly unbroken beach deposits, so well known all over the Island, are called Lloyds. They consist of coarse, silicious sands and gravels from which softer elements were thoroughly removed by milling action of the tides. The thin wedge of sediments between Lloyds and bed rock ranges in thickness from only a few feet in northern Queens, to several hundred feet under the Rockaways.

The Lloyds is one of the most important water-bearing horizons in Long Island. It is the most persistent and unbroken of the Cretaceous strata, apparently affording a highly permeable zone at the bottom of the Island's sediments, through which water interchange may freely be effected between eastern counties and the western end of the Island. Its thickness varies considerably because of the existence of upper and lower members separated by clay partings. It ranges from about El. 40 when a single member, to upwards of El. 100 where upper and lower members occur with clay partings.

In some places along its line of evanishment, the Lloyds is directly in contact with the rock. It is difficult to determine where Lloyds may have originally contacted bed rock in Brooklyn and Queens. Its bottom has a more gentle pitch landward than the rising gradient of the rock beneath, but it may have extended across Brooklyn to rock contact along contour 250 feet below present sea level. Its crop line rises as it extends northeasterly of Flushing Bay and passes under the Sound. Possibly, at one time, it may have continued across the Sound and overspread basement rocks in the extreme southeastern part of Connecticut. Subsequent land stream erosion has removed much of the Lloyds in Brooklyn particularly, as well as parts of Queens and beneath the Sound. Above the Lloyds and persistently overspreading it, are layers of pure, even marl-like clay which appear to afford an impermeable seal, except where they may have been cut through by later disturbances. These have quite distinctive markings and coloring, frequently being deep red or "salmon pink," intermingled with a peculiar mottling of white, light grey and dark grey clays. Such fine sediments are obviously offshore deposits in deeper waters beyond the line of barrier beaches. The reddish or "pink" clays

apparently were transported seaward from erosion of Triassic rocks in the Connecticut central lowland. The white and grey mottled clays may be from the crystalline rocks.

Subsequently, there was deposition of fine sediments, totaling upwards of 150 feet to possibly 250 feet above the Lloyds. This was followed by another phase of beach or barrier beach deposition, which is differentiated as "Magothy Sand," to distinguish it from Lloyds. The Magothy Sand is more lenticular in character than stratified. Its attenuations, however, seem to be persistent enough to afford relatively widespread means of water interchange along its horizon. Drillers have occasionally encountered it in Queens south of the Terminal Moraine. The fine sediments separating it from the top of the Lloyds have the characteristic wedge-like decrease in thickness as they go northward, so that it seems possible in the vicinity of the Terminal Moraines, the folding and disturbance of Ice thrust may have created some interconnection between the Magothy Sand and the Lloyds.

The littoral Magothy Sands were overspread by offshore deposition of fine sediments from Connecticut rock erosion. Mixed with these are occasional pink or red hued Triassic clays termed "Upper Pink" herewith to distinguish them from the "Lower Pink" and mottled clays above the Lloyds. The disconnected and overlapping features in Cretaceous laminae, from coastal axis oscillation, are more noticeable commencing with the Magothy Sand. Distribution of reddish sediments from Triassic rocks seems to occur without rhyme or reason. The irregularities of the Magothy Sand itself may have been caused by oscillation.

The sediments comprising the remainder of deposition beneath the Cretaceous land surface are predominantly fine, with generally grey or dark coloring. They afford a practically impermeable covering of water-bearing formations in the Cretaceous, except where later erosion or Ice disturbance may have disrupted their continuity. It is difficult to tell how long land sinking continued before the Tertiary rise of the coast. Logically, this may have extended through early Tertiary (Eocene) just as occurred in New Jersey. However, there are certain indications of a differential in coastal rise and fall, because of a break in the rock structure along the lower Hudson Valley. Whatever may be the reason, correlation between the upper Cretaceous-lower Tertiary formations of Long Island and New Jersey is not clearly determinable.

When land sinking finally stopped, and Tertiary emergence bereft the ocean floor of water protection, the incoherent coastal plain fell easy prey to Connecticut land drainage. Apparently, hundreds of feet were removed from the top of the rising sediments. The thin overlapping in Connecticut was gradually removed and transported seaward for redeposition. By the close of Tertiary time, drainage topography must have established an Island somewhat similar in appearance to the present one. A series of earlier valleys may have been cut across the Island area by Connecticut

rivers working seaward, but as landward drainage re-established itself on rock it came under influence of the prevailing eastward and westward slopes towards Connecticut's central lowland. Eventually, it converged via the Connecticut Valley to meet the coastal plain somewhere in the vicinity of New Haven. Presumably, this must have turned the river southwestward along the contact between bed rock and coastal sediments, just as has happened with all the south Atlantic coast rivers. Furthermore, this course may have been the shortest outlet to the sea via the Hudson.

Thus, a major valley was cut along the Sound from New Haven to Little Neck and thence across Queens and Brooklyn towards Coney Island. This is generally known as the Sound River Valley. It is possible other valleys may exist in the old Cretaceous land surface eastward of this one. Nothing, however, has as yet been very completely developed to reveal their position. There are certain indications of a buried valley under the western part of Nassau, and possibilities of others further eastward, in Suffolk. If the cutting of the Hudson's rock gorge commenced in later Tertiary time by land uplift, this may have been in the form of Long Island uptilt at its westerly end, which naturally would move the outlet of Connecticut drainage eastward as the tilting progressed.

Deposition of old, decayed gravels, that is, Mannetto or Bethpage, may logically have occurred in the Sound River or other buried Cretaceous valleys during Tertiary time. Irrespective of what intervening rises and falls the coast may have experienced, Tertiary appears to have been predominantly an erosion interval, especially during its closing (Pliocene) period. The major streams had plenty of time not only for widening their valleys, but to carry away intervening highland as well. It is probable that long estuaries of the sea extended into the flat, meandering valleys, resulting in extensive tidal marshes. Likewise, combined base leveling and side stream erosion must have formed a low rounded intervening highland. The action of waves and tides upon all these sediments probably built up barrier beaches, off the southerly shore, much the same as now found along the Island. These beach deposits were, of course, limited in their landward travel by the prevalence of land elevation over sinking. In general, however, the topography of the old Cretaceous land surface must have been not unlike that found in today's coastal plain areas.

Tertiary climate was mild, possibly comparable with that of Georgia. Long exposure to sunlight and oxidation would tend to give the surface of upland between valleys a generally reddish or yellowish cast, similar to that of present day southern coastal plain areas. Intensive vegetal growth in the wide marshy valleys would result in grey, blue or black clays, with the distinctive laminations of tidal marshes, just as now found in New Jersey's low marshy estuaries. The long exposure of that old Cretaceous surface to weathering naturally resulted in removal of incoherent

or sandy elements, leaving a crust predominating in clays, hardpans and similar compacted residual materials. Scrutiny of well logs now available in Kings and Queens seems to bear out these conditions and to provide markers whereby the old land surface may be located at sufficient points to form a fairly accurate picture of its undulations and irregularities.

It is well to pause now in our review of the history of Long Island's sedimentation and picture the general condition of the Cretaceous land surface at the western end, before the Ice got in its destructive work. The structural changes effected during unconformable deposition from ensuing glacial agencies wrought profound alterations in that original surface. The Sound River Valley apparently left the area of the Sound proper somewhere under the northern part of Great Neck, with a trough lying possibly 250 feet below present sea level. Its axis apparently lay along a line projected from somewhere under southern Little Neck Bay towards the western terminus of Interborough Parkway—say, the intersection of Fulton and Jamaica. By the time it reached the northeast corner of Flatbush, the Valley bed was definitely riding on bed rock, as proven by borings at 98th and Rutland. Consequently, it seems inevitable that the left Valley wall scarp exposed a complete section of Cretaceous formations through to the basal Lloyds. The length of exposure of the Lloyds, however, may possibly be limited to the sector between Maspath and East New York, because after riding on bed rock through the Flatbush area, the Sound River Valley again passed onto Cretaceous sediments before reaching Coney Island. The maximum depth of the Valley in southern Brooklyn appears to lie 400 feet to 425 feet below present sea level. This indicates a fall of approximately 10 feet per mile along the Valley axis from Little Neck to Flatbush.

Whether the indicated Lloyds outcrop, along the scarp in northeast Brooklyn, affords direct contact between Jameco and Lloyds cannot be stated. It is possible this exposure may subsequently have become sealed, or blanketed, either by Valley wall alluvium or side wall sloughing of overlying clays. The important thing to note, however, is that between Little Neck and northeast Brooklyn, evidence distinctly indicates the bottom of the Valley cut through successive Cretaceous laminae, and ultimately reached the Lloyds northeast of Flatbush. Through Queens, the Lloyds was apparently not exposed but remained under the bottom of the Valley covered by variable thickness of the clays deposited between it and the Magothy Sand.

In Brooklyn, south of parallel 40° 40′ latitude, it should be noted that the rock contours run southwestward, across the projection of a valley axis assumed to run from Ridgewood to Coney Island. The Valley itself, moreover, assumes a different aspect. Its bottom takes on the character of a widespread estuary or embayment, with relatively flat bottom, averaging approximately 400 feet below present tide, easterly of the rising bed rock gradient. This is an erosion phenomenon designated in this report as the

"Brooklyn Basin." It may be base leveling arising from a prolonged period of stationary land elevation at approximately 400 feet; or it may be side cutting by scour of the Hudson's debouching waters as the rising land created the Hudson gorge. The outpouring Hudson was obviously deflected by the Staten Island bluffs towards its left Valley wall, under Bay Ridge and eastward. This would tend to remove soft Cretaceous sediments which were above the emerging bed rock in the area stretching south and southeast of Gowanus Bay beyond rock contour —200 feet. When the emergence exposed rock contour —400 feet, constriction on the Staten Island side (and the consequential deflection) ceased, because of the sharp seaward rock drop. Thereafter, outpouring Hudson waters, passing beyond control of the Staten Island bluffs, would tend to cut a normal v-shaped valley in the sediments extending seaward. Between these two hypotheses on how the Brooklyn Basin may have been formed, that of erosion by the outpouring Hudson seems preferable. Convincing data are lacking elsewhere under the Island to support a stationary period of base leveling.

Moving over to the right wall of the Sound River Valley, we find Cretaceous remnants still persist nearly everywhere west of a line projected from Willets Point to Gowanus Bay. The right Valley wall appears to have been constricted somewhat by irregular projections of rock knobs in the western end of the Sound, the East River and Astoria. Evidently, remnants of the thin overlapping Cretaceous fringe remained behind the protection afforded by higher knobs throughout the period of Sound River Valley erosion. It is probable, however, that these sediments were somewhat modified or reworked by side drainage as the Valley was forming.

In Queens, east of the Sound River Valley and north of Jamaica Bay, was typical low rounded Cretaceous highland, similar to the old land surface of the balance of the Island. At the culmination of Sound River Valley development, when the land was presumably 400 feet higher than now, the relief in Queens ranged downward from an approximate average elevation of 200 feet, with peaks possibly standing as much as 225 feet above the Brooklyn Basin floor. Along the Nassau County line, south of the Terminal Moraine, meager well data indicate a general pitching of the old land surface eastward. Apparently, it drops about 100 feet below the mean elevation of Cretaceous sediments to the west. This may be an upper section of the sloping side wall of a buried Cretaceous valley in western Nassau. Under Jamaica Bay, Cretaceous relief seems to take on more or less terraciform characteristics, dropping upwards of 200 feet from mean relief elevation along the old Brooklyn aqueduct by the time it reached the Rockaways.

This completes a broad picture of the old Cretaceous land surface in Brooklyn and Queens before Pleistocene sediments spread over it. Presumably, the full development of the Hudson canyon was consummated before deposition of Jameco gravels commenced in the Sound River Valley. It is generally believed that there exists

a Hudson canyon somewhere off Coney Island and the Rockaways, and geodetic records indicate this to be much deeper than the floor of the Brooklyn Basin. Evidently, then, the Sound River Valley is hanging where it meets the Hudson gorge. It may be that transitional Tertiary sedimentation, of the character described by Veatch and Crosby, was carried into the Hudson gorge during an interval between the excavation of the Sound River Valley and subsequent Jameco deposition; or, it may be that earliest Jameco sediments were swept into the Hudson estuary. Apparently, however, when land drainage first brought glacial erratics into the vicinity of the Island, the ocean shore was far seaward of its present position.

Long before the Ice reached Long Island Sound, in fact, possibly before it reached Connecticut, there was littoral deposition of glacial material by streams flowing through old Cretaceous valleys. Remoteness of the Ice front did not prevent heavy flows of melting glacial waters from carrying coarse sands and gravels down valleys which extended from the Ice front to the sea. Water undoubtedly poured through these valleys in torrential volume, similar to what is annually witnessed in Alaskan rivers. There was ample velocity to carry all fine sands and silts far into the sea, leaving only coarse sands and gravels in the valley bottoms, landward of the shore line.

Deposition of Jameco sands and gravels commenced in the lower reaches of the Sound River Valley and steadily progressed up its estuary. Undoubtedly, certain of these sediments were carried seaward, beyond Coney Island, where they would encounter tide and wave action. This would convert them into beach-type deposits, possibly forming barrier beaches offshore because of the heavy flows of the Sound River. The formation of barrier beaches would naturally result in lagoon-type sedimentation behind them. Therefore, it is logical that as the deposition of Jameco was built up in the Brooklyn Basin, interlaminations of fine sands and clays would occur. These features are quite noticeable in such wells as have penetrated through the Jameco in south Brooklyn.

The accumulating weight of approaching Continental glaciers steadily depressed the land, causing the sea to encroach first into valleys of the Cretaceous land surface, and ultimately, as the land continued sinking, to cover the entire Island area. The deposition of glacial gravels and sands progressed landward behind the advancing shore line, accompanied by offshore deposition of fine dark colored sediments and clays. Gradually, the valleys and depressions were filled with the more or less permeable sediments which are collectively designated as the Jameco in this report. It should also be noted that, simultaneously with coastal depression and deposition of remote erratics, occurred certain reworking of local Cretaceous materials by side streams near the coast. Occasionally, therefore, interlaminations of Cretaceous and glacial sediments are found in the Jameco filling of the valleys which may logically be considered Jameco because they were deposited simultaneously with it. This feature is particularly noticeable

in the area lying between Flushing and Gowanus Bays. Jameco filling of the Sound River Valley and Brooklyn Basin continued up the valley walls to the level of higher land under Queens, when outpouring waters from the melting Ice spread their sediments over what was by this time a relatively flat western end of the Island. This upper deposition has more or less heterogeneous classification as would be expected from the vacillations of melting Ice outwash over a relatively flat front. It filled all depressions in Queens, coarser sediments accumulating near the bottom and fine sands and clays precipitating slightly offshore to form an impermeable blanket over them.

This offshore deposition of clays and fine sands is generally known as the Gardiners. It began off the South Shore before the Cretaceous land surface had entirely submerged. Its initial deposition in the Brooklyn Basin commenced at lower elevation because the sea encroached there first. Subsequently, it rose steadily landward, reaching an elevation of approximately 100 feet below present sea level along lat. 40° 40′. North of this, it continued rising slightly, and probably along the North Shore, stood about 80 feet below present sea level, before the Ice disturbed it.

The Gardiners as originally deposited was a peneplain that formed a practically impermeable blanket over all of Kings and Queens Counties. It was subsequently arched, folded and in places removed to the north of the Terminal Moraines, but appears to have about its original position southward of them. In Jamaica, Queens Village and Hollis, there exists a peculiar dome-like elevation of the Gardiners, which may be arching from shove of the Ice. It varies decidedly in thickness, ranging between 15 feet to upwards of 35 feet over most of the area south of the Moraine, but is too disturbed north of it to make estimates of average thickness. Occasionally, only a few feet are found below the Moraine, where it appears to have been eroded by outwash from the Ice front. It is possible that in spots, the Gardiners may have been completely removed in this manner, but in general, it apparently affords a widespread impermeable seal, covering the Jameco everywhere south of the Moraines, in Queens and over much of the Brooklyn Basin. It is revealed definitely in wells drilled south of Jamaica Bay, at depths ranging from 190 feet to 200 feet below present sea level. Under Coney Island, however, its position is not definitely known because well data are so meager. However, it should be encountered below El. —200 according to depths at which it is found further north, particularly in Flatbush. During the progressively northward deposition of Jameco and Gardiners, the Ice front steadily moved southward, narrowing the belt between them. Apparently, there must have been a considerable accumulation of sand and coarser sediments as littoral deposits over the Sound and southern part of Connecticut before the Ice reached southern Connecticut. These coarser sediments were among the first to undergo redistribution from outwash action of the nearing Ice front, and therefore make up a goodly

portion of the first deposition of gravels and sands immediately above the Gardiners. Like all frontal Ice deposits, their deposition was irregular both in thickness and classification. Moreover, they were carried much further south in some places, than others.

At this point, it may be interesting to mention an indicated parallelism shown by Crosby's conception of a thorough base leveling epoch at the close of his Pliocene Base Level, which resulted in the deposition of the Yellow Gravel Series immediately over fine sediments blanketing the Island's surface. It will be noted that the dark colored Gardiners clays and fine sands formed a relatively flat plain, corresponding to Crosby's indicated basement of his Yellow Gravel Series. The overspreading, coarse sands and gravels from outwash reworking by the nearing Ice front have the same chronological position as the Yellow Gravel Series. Subsequent well borings reveal more evidence of glacial than beach characteristics in these formations under Kings and Queens, though in a few parts of the Sound River Valley in Queens occur highly silicious beach-type sands. These appear to be redistributed Cretaceous sediments that may have been ploughed up somewhere in the vicinity of the Sound.

The original peneplainal Island surface, spreading out from the shore when the Ice reached it, suffered great disturbance when the front of the glacier came in contact with it. Until the Ice reached the Sound it was riding substantially on a bed rock basement. Such deposition of sediments as preceded its moving front had been washed seaward and spread over the Gardiners. When the glacier reached the Sound, however, it ploughed into sediments overlying bed rock in the manner of a giant bulldozer. These were pushed ahead as the weight and force of the Ice Front accumulated. Ultimately, the bottom ice reached a point in resistance of material confronting it, where it could go no farther; when the generally "plastic" character of the glacier caused overriding. There were two agencies tending to create violent distortion in sediments along the North Shore. First, the underlying "toe" of buried ice which pushed, crumpled and even folded deep sediments, including Cretaceous, ahead of it. Second, overriding Ice which tended to scrape off upper parts of the sediments, including sections of lower formations that were folded or arched. The underlying "toe" apparently projected into the North Shore, along a very irregular front, creating deep indentations which have subsequently become the bays of the North Shore. There seems no better, or more logical, explanation of the North Shore bluffs and plateaus with deeply indented bays intervening, than Glacier impact which buried the bottom ice and conducted all subsequent deformation and sedimentation by over-riding.

West of Little Neck Bay, the bulldozing thrust of the Ice appears to have carried the right wall of the Sound River Valley considerably southward of its original position. Moreover, the fingers of projecting bottom Ice which formed Flushing and Little Neck Bays, apparently folded or heaved Cretaceous sediments under

the middle of the Valley in such manner as to intermingle the original contact between Jameco and Cretaceous sediments. Westward to Flushing Bay, and probably further, the original width of the Valley appears to have been narrowed, and the underlying Cretaceous sediments to have been arched and possibly folded. The valley-filling sediments were likewise distorted, tho folding of incoherent Jameco gravels would not be evident from well logs. However, the clays in the Gardiners show rather definite evidence of folding by the extremely variable depths at which they occur in wells drilled only short distances apart. In the Whitestone Peninsula, Cretaceous sediments along the right Valley wall may have been moved en masse since they appear to be less disturbed than in the Valley proper. The Lloyds underlying this area, however, appears to be considerably disturbed and altered structurally, suggesting the possibility that the more coherent overlying clays slid upon these underlying gravels.

Between Flushing Bay and Wallabout Basin, Cretaceous valley wall remnants do not appear to have been moved. Rather, they indicate Ice scraping and reworking, with minor arching and folding. The belt stretching from the original shore line overlap of Cretaceous by Gardiners, to the Brooklyn moraine, has undulations in the Gardiners, even possibly occasional slight folding, but no break in the Gardiners seal shows up in well logs. In general, northwest of a line stretching from Flushing Bay head, to the southeast corner of Brooklyn Navy Yard, there seems to be intermingling of Cretaceous and Post-Jameco sediments. This is accompanied by occasional folding or possibly overthrust, and the whole mantled by a relatively thin surficial covering of Wisconsin sands and gravels.

Southwest of Wallabout Basin to Gowanus Bay, Cretaceous remnants are highly disturbed and apparently intermingled not only with Gardiners, but to a certain degree, Post-Gardiners sands and gravels. The "normal" Gardiners –100 feet elevation is indistinguishable in the peninsula lying between Buttermilk Channel and the Gowanus estuary, tho bed rock ranges down to 175 feet below tide. Instead, there is a conglomeration of sedimentary structure that has been reworked in such a manner as to leave lenses or irregular laminae of both permeable and impermeable sediments now filled with highly saline water. The Gowanus Canal roughly follows the 150-foot contour. The top of typical Jameco gravels apparently would have contacted bed rock along the 150-foot contour unless preoccupied by Cretaceous remnants or side wall reworking of these remnants. Yet, Jameco gravels appear to be lacking east of Gowanus Canal as far as Third Avenue. Well data ranging up to depths of as much as 200 feet indicate the existence of some sort of a "dike" of impermeable formations that cuts off the fresh water-bearing Jameco along a line roughly assumed to parallel Fourth Avenue southward from Butler Street. In the area lying generally northeast of the head of Gowanus Canal, this impermeable zone or "dike" seems to merge into Gardiners that

rests in contact with the rising bed rock. The location of the eastern face of this so-called "dike" cannot, of course, be even approximated because well data are too meager. In general, eastward of Fifth Avenue, such wells as pass through the Gardiners develop fresh water in what appears to be typical Jameco sand and gravel. West of Fourth Avenue, wells in formations down to –200 feet produce water usually saline, indicating free permeation of salt water around the Gowanus shore line. Between the fresh and salt water areas, impermeable sediments appear to occupy the zone of Jameco deposition between Gardiners and bed rock. Bed rock, north of Butler Street, in the Wallabout-Gowanus Canal Peninsula is not generally more than 100 feet below tide. Therefore, the sediments are predominantly Post-Gardiners, occasionally mixed with reworked Cretaceous.

The earlier Queens (Ronkonkoma) Moraine, north of Newtown Creek and stretching along Queens Boulevard, was greatly modified by the final onset of the glacier that terminated along a line from Bay Ridge through Prospect Park to the cemetery area in northeast Brooklyn. The movement of the Ice to each moraine scraped off certain Post-Gardiners outwash deposits, which preceded the Ice Front on the Island. However, the greatest deformation of underlying structure, as well as removal of outwash covering of the Gardiners, came during the first advance to the Queens Moraine. The final movement into Kings County apparently confined its maximum disturbance to northwest Brooklyn, between Gowanus Canal and English Kills. It is dubious whether Ice scour during the final thrust to the Brooklyn (Harbor Hill) Moraine extended deep enough to materially disturb Gardiners clays, except along their shore line contact with Cretaceous remnants under the above mentioned northwestern section. Obviously, there must have been some scraping off of loose outwash sands and gravels that blanketed the Gardiners in northern Brooklyn, but the southward moving Ice Front left a thick mantle of highly permeable Wisconsin deposits behind it. Apparently, the moraine materials rode over earlier Post-Gardiners outwash gravels, leaving a permeable layer sandwiched between unclassified boulder till and the Gardiners beneath.

In Brooklyn, therefore, we find a relatively free means of water transfusion above the Gardiners, regardless of the Terminal Moraine. Moreover, between the bottom of this Brooklyn Moraine and the Gardiners there seems to exist a general water-bearing horizon. On the other hand, the older Ronkonkoma Moraine in Queens appears to have impermeable sediments, possibly elevated Gardiners, intermingled with unclassified moraine material, except where it crosses the Sound River Valley in the general Flushing-Bayside district. This would indicate a restriction of some sort against free water passage through or beneath the Queens Moraine, but there are no reliable well data upon which this may be proven.

When the Ice retreated, and subsequent to that time, occurred modification of the surface which left a general mantle of permeable, brown Wisconsin sands all over Kings and Queens

Counties, except small areas of rock outcropping in Long Island City and Astoria. These Wisconsin deposits form thick outward slopes, stretching south from the Moraine hills, and afford a highly absorbent sponge for the accumulation of rainfall. Between the moraines in Queens, north of Grand Central Parkway, they are piled above unclassified moraine deposits to form the highest area in the Counties. This is a catchment area underlain by an elevated water table which slopes downward to all the remainder of Kings and Queens. It is largely directly over the Sound River Valley, and should afford excellent means for percolation of water below the Gardiners wherever it may have been removed by ice scour. Westward of this plateau-like overspread, thick Wisconsin deposits continue between the diverging moraines across Queens and Brooklyn, and provide an excellent Post-Gardiners aquifer. Towards the westerly end, near downtown Brooklyn, is the most concentrated industrial well development of western Long Island which has resulted in the formation of a notable depression in water levels that will be discussed later.

In general, the highly permeable Wisconsin and underlying Post-Gardiners gravels constitute the most important source of industrial water development in Kings and Queens Counties. The water stored in them seems to be precluded from percolation into the deeper Jameco or Cretaceous aquifers because of intervening Gardiners clays, except at scattering points where the Gardiners may have been removed. In fact, the only area which definitely indicates a possibility that these surficial waters may be percolating through the Gardiners seal, seems to be the Sound River Valley area between Flushing and Little Neck Bays. Here, folding and arching of the Gardiners may have resulted in its removal, in places, by Ice overthrust, so that limited amounts of water accumulated in the Post-Gardiners sediments may be recharging the Jameco, or even getting into the Lloyds.

# III

## TERMS AND DESCRIPTION OF FORMATIONS

*A.—Bed rock*

The basement rocks have a generally metamorphosed, granitic appearance, except where exposures of dolomitic limestones occur under East River and in the vicinity of Long Island City and Astoria. The East River, at present, occupies a trough in the bed rock which apparently follows the line of dolomitic limestones. Minor trenchings are found under Long Island City and along Newtown Creek. The Newtown Creek trench has a saddle shortly east of Whale Creek, from which point the rock slopes both westward and eastward. A deeper trench underlies the left bank of the East River in Williamsburg. It runs nearly due south, passing to the east of Wallabout Channel and running towards the Sound River Valley. This suggests a probability that the East River, at one time, had a more directly southward course into the Sound River Valley and that its present westerly turn at the Navy Yard is a more recent development.

The deep Hudson canyon is presumed to range upwards of 600 feet below present sea level. Practically nothing is known about the location of the axis of its gorge south of the Battery, but presumably it makes an eastward bend off the Staten Island bluffs, curving under the extreme southwestern shore of Bay Ridge to a point somewhere in the vicinity of the western end of Coney Island.

Numerous irregularities exist in the bed rock surface above its —100-foot contour, with knobs projecting above sea level in many parts of Long Island City and Astoria. Contouring of bed rock from well logs now available indicates quite regular peneplaination from northwest to southeast. Below the—100-foot contour-line it holds to a definite and persistent gradient that carries it to a depth of something over 1300 feet under Far Rockaway.

In the vicinity of Newtown Creek and extending northward towards Rikers Island, cracks and fissures are found down to depths of approximately 300 feet. Many of these provide water yields ranging from as little as 40 gallons per minute to nearly 200 gallons per minute from a single well. Usually, this water is quite saline, but rock drilling history in Maspeth and Woodside indicates that fresh water may be found in rock fissures eastward of Long Island City, towards Flushing Meadows. Immediately overlying bed rock there frequently occurs undisturbed, soft decayed rock particles which are usually impermeable. Occasionally, however, decayed rock particles have been slightly reworked and interlaminated with Cretaceous sediments affording permeable lenses yielding some water. The thin coating of clays, fine sands and decayed rock in northwestern Queens apparently acts as a seal to prevent passage of overlying water into rock fissures below.

There is one isolated indication that bed rock in Brooklyn deviates from the regularity of its southeastward pitch. A Flatbush Water Company's test well (K–523) at Newkirk and Nostrand struck what appeared to be rock at approximately elevation—379 feet. The rock material, however, is a gray sandstone with a distinct reddish tinge. The well continued in this material to El. —488 without encountering normal bed rock. This suggests the possibility that the Sound River Valley may contain a pitching rock trough near its mouth which graded down into the Hudson canyon. The hard gray sandstone (?) may be compacted or partially solidified old sediments, possibly the Potomac (?) mentioned by Crosby.

*B.—Cretaceous*

There is no satisfactory evidence that sediments older than Cretaceous exist anywhere under Kings and Queens, except the lone datum of the above mentioned test well. Possibly, Lower Cretaceous sediments lie further down the rock slope, eastward of the present Island shore line. For purposes of simplicity, all formations deposited prior to any erratics from melting glacial waters are collectively termed "Cretaceous" in this report. This means formations underlying the old Cretaceous land surface, upon which Jameco, Gardiners or older glacial deposits rest. The essential features about Cretaceous deposition have already been discussed so it is unnecessary to repeat them.

*C.—Sound River Valley*

Any repetition in the way of description of Sound River Valley formation is superfluous since it has already been so thoroughly presented. Apparently, Connecticut drainage followed a course similar to what is now so evident in the Delaware and other major Atlantic streams southward of it. Its line of discharge, seaward of the present Connecticut coast, was subsequently altered by agencies having no parallel in the more southerly rivers. Profundities arise in trying to correlate possible courses of buried Connecticut drainage over Long Island, with phenomena accompanying the erosion of the Hudson's gorge, because later glacial disturbances obliterated the evidence. If weight be given to the possibility of land uplift sloping the Island eastward from the Hudson, as its canyon deepened, then the course of drainage across the Island could have occupied successively eastward positions as the western end was lifted. From what available well logs reveal, the Sound River Valley appears to have an elevated floor where it enters the Hudson's rock gorge. This is not a normal condition. We must, therefore, picture the Valley's development under either of two assumed conditions: that canyon excavation preceded Valley formation and was filled with sediments up to the Valley level; or that the Valley became an abandoned channel in favor of more eastward outlets of Connecticut drainage, as the Hudson's canyon deepened. The existence of such voluminous, and deep, glacial filling under south-

ern Brooklyn, with typically interlaminated sedimentary characteristics, is noteworthy. It impels the belief that it could only have come about through the agency of a major stream that extended far northward to the Ice Front.

*D.—Brooklyn Basin*

Very little can be added to the Brooklyn Basin description given earlier in this report. Whether it exists under, and westward of, the Fort Hamilton-Prospect Park morainal hills must remain in doubt until further drilling reveals the facts. No wells are known to have reached bed rock in this area, except in the vicinity of Gowanus Bay. In fact, from Greenwood Cemetery south to Gravesend Bay, there are only dubious well data on the depth of the Gardiners, and no reliable record of the position of the Jameco. As far as can be determined from available records, all water developed in Brooklyn west of McDonald (Gravesend) Avenue comes from Post-Gardiners formations, except whatever draft the Flatbush Water Company may be pumping.

It seems possible that west of the Brooklyn Moraine, below Gowanus Bay, sediments immediately above the rock may persistently contain certain amounts of outwash or reworked Cretaceous mixed with their glacial content. This conjecture arises from the probability of outwashing fine Cretaceous sediments carrying down the rock slope from north of Gowanus during the deposition of Jameco gravels. When, and if, well data should become available, it is important to determine whether glacial erratics are intermingled with other sediments near the rock, because if any glacial sediments exist, then the entire mass was deposited concurrently with the valley-filling in southern Brooklyn.

Between Flatbush and Coney Island, the data are also meager, the principal source of information being one deep well at Mill Basin which seems to check the general Brooklyn Basin floor at approximately El. –400. East of Flatbush, a well recently completed to rock, north of Fresh Creek, at Vansinderen and Newport, yielded excellent evidence of glacial erratics to a depth of 425 feet below tide. Apparently, the slope of the Cretaceous scarp indicated under Ridgewood Pumping Station pitches sharply to the Brooklyn Basin floor before it reaches East New York.

*E.—Jameco*

Jameco, as previously stated, comprises all formations between the old Cretaceous land surface and the Gardiners' blanket of dark colored clays and fine sands. By far the greater percentage of Jameco deposits are relatively coarse glacial erratics brought in by streams that flowed from the melting Ice Front. However, there was a certain amount of slack-water precipitation of fine grayish colored erratic clays and sands along the valley walls, noticeably, the right wall, extending southward from Whitestone, possibly as far as Bay Ridge. Simultaneous reworking by contributary streams carried side-wall Cretaceous remnants into the valley and

deposited them as interlaminations of glacial Jameco deposits. These streaks of clay and fine sand may easily be misinterpreted as the Cretaceous land surface in place.

Earliest Jameco deposition in the Sound River Valley was probably not initiated until after it had made some progress in Cretaceous estuaries east of Queens County. The Brooklyn Basin was apparently slightly above sea level, though slowly approaching it as the land depressed under the accumulating weight of the Glacier. The coarser Jameco sediments were, at first, deposited littorally seaward of the Island's present South Shore, bringing them under the "milling" activity of the tides which tended to polish and round the particles into beach-type deposits. They apparently lost much of their angular glacial characteristics, so that coarse Jameco deposits, seaward of Cretaceous valley estuaries, should appear as buried beaches, or even barrier beaches. Such a beach character in the Jameco horizon was clearly revealed in a recent well drilled at Lookout Point, east of Long Beach. The bottom Jameco deposits under Coney Island likewise appear to have beach characteristics, from the meager data available.

The volume of discharge through the Sound River Valley should have increased as the Ice Front came nearer. Therefore, under this hypothesis, deeper Jameco deposition in the Brooklyn Basin would have certain lagoon-type or tidal-marsh characteristics in the way of dark colored interlaminations of clays or fine sands precipitated behind offshore beaches of coarser Jameco sediments. These would grade upward into coarse gravels and sands as the flood of water increased from nearer approach of the Glacier's Front.

Along the right Valley wall, the top of Jameco filling in the Brooklyn Basin should, theoretically, contact the old land surface at El. –150, more or less. This would bring it approximately under the Gowanus Canal. From there, through English Kills to Great Neck, the top of the Jameco should rise steadily, following the level of landward advancing shore line during its deposition. There seems to be quite positive evidence that Jameco contact with the Cretaceous surface along the right Valley wall, between Gowanus and Flushing Bays, is a merging of finer impermeable sediments, overlapped by Gardiners, which protects the Jameco horizon against inroads of salt water. Below the Gowanus Bay area, paralleling the periphery of the Hudson gorge, nothing is known of the character of sediments underlying Post-Gardiners. Possibly, the deposition of silts in the Hudson canyon spread over the periphery of its left wall to intermingle with Jameco filling and form a relatively impermeable zone back from the harbor shore line. In fact, any of the eddy phenomena liable to occur at the fork of Hudson and Sound River Valleys could provide impermeable deposition from admixture of fine sediments. In general, it seems likely the Jameco is relatively impermeable or otherwise protected by sealing against salt intrusion, from Gravesend Bay along the shore line to Gowanus, and thence across Brooklyn and Queens to the emergence of the Valley trough into the Sound at Great Neck.

Across the mouth of the Valley, at Coney Island, the only possibility of Jameco sealage against salt depends upon whether impermeable Gardiners clays persist over southern Brooklyn and seaward beyond Coney Island. For the present, we must remain in doubt since well data are so meager. The only facts available are recollections by drillers of old wells, that salt water existed at El. –258 under Coney Island, and at El. –228 at Mill Basin. In each case, fresh water was developed under impermeable strata which underlay the reported salt zones. It should be noted that the depth of these salt sealing strata may conceivably be the Gardiner's horizon.

Jameco deposition continued northward, covering the Valley and passing into the Sound area. It must have provided thick, incoherent, littoral deposits over the northern part of the Sound, including Connecticut's southern shore, close to the advancing Ice. These, the Ice Front promptly redistributed above the Gardiners as it moved into the Sound area. Latterly, the trough of the Valley under the Sound was apparently closed and sealed against salt contamination by the bulldozing action of the Ice. The Jameco overspread of the Cretaceous land surface in southern Queens and Jamaica Bay is evidently very effectively blanketed by impermeable Gardiners clays down to the South Shore line. Therefore, the source of fresh water supply of the Jameco must largely be from Nassau County, except for possible local infiltration in the Sound River Valley area, north of Hillside Avenue in Queens.

*F.—Gardiners*

In certain respects, Gardiners is the most important structure in western Long Island, because it so generally seals underlying aquifers not only against recharge, but salt water contamination. Undoubtedly, certain openings must exist through which rainfall percolates into the Jameco beneath it, but these appear to be very scattered, as evidence of them is lacking in most of the wells. Direct contact between permeable Post-Gardiners and Jameco sediments may exist in northern Queens under the Terminal Moraines, and possibly in the extreme eastern part of the Brooklyn Basin in the vicinity of East New York, provided single well records at each of these points are reliable. Except for these two wells, gray or dark colored impermeable clays or fine sands are found in all other logs at depths correlating with the Gardiners horizon.

Gardiners varies decidedly both in thickness and in color. It ranges from an occasional thickness of only a few feet to upwards of 35 feet with predominantly gray, "blue" or even black coloring. The sandier phases are usually light gray.

Its characteristics north and south of the Terminal Moraines have already been described, together with the pitch of its horizon south of lat. 40° 40′. Apparently, it overlaps and lies in contact with Cretaceous or impermeable Jameco valley wall deposits everywhere from Little Neck Bay to the vicinity of the head of Gowanus Canal.

The pitching character of the Gardiners in south Brooklyn is best indicated in the Flatbush Water Company wells which show

a range in elevation of its surface from about 100 feet below tide in northeast Flatbush, down to depths ranging from 175 feet to 190 feet at the south end. These measurements are recorded to the top of the Gardiners and do not seem to indicate a very accurate picture of its original surface. The upper phases are the sandier ones and, therefore, would present little resistance to redistribution, even under shallow coastal waters when outwash Ice agencies came in to play upon them. The persistence of Gardiners north of the moraines indicates that cushioning against ice scraping must have been provided by outwash deposition above it before overriding Ice came in contact with it. In the Sound River Valley area immediately south of both Flushing and Little Neck Bays, Gardiners appears to have been more folded than anywhere else in the area covered by this report. There appears to be an accordion-like "gathering" or folding ahead of the advancing fingers of underlying Ice which formed the indentations that are now bays. Regardless of elevation or disturbance north of the moraines, Gardiners seems to contact Cretaceous sediments everywhere along the right wall of the Sound River Valley between Little Neck and Flushing Bays. It has been considerably elevated at the head of Little Neck Bay and under adjacent parts of Little Neck Peninsula, by arching or folding from Ice thrust. Despite this disturbance, however, a seal against salt infiltration from the Sound exists eastward from the Whitestone Peninsula, across any permeable filling of the Valley trough, where it emerges into the Sound. This seal may consist of intermingling Gardiners with ploughed up Cretaceous clays from beneath the valley floor. One can only guess what may have happened, but a seal obviously exists.

In general, comparative study of water tables, pumping operations and well log stratigraphy strongly indicates shore line sealage against salt water infiltration of the Jameco everywhere, except for a dubious stretch from Gravesend Bay to Jamaica Bay. The association of Gardiners with this evident (or apparent) line of sealing seems to justify an assumption that Gardiners is the key to it. Between Gravesend and Jamaica Bays, the Gardiners horizon is only doubtfully indicated by the meager well data available and, obviously, steps should be taken to obtain additional data which are so urgently needed.

*G.—Post-Gardiners*

Post-Gardiners sediments falls under three classifications, viz.—outwashed coarse gravels and sands immediately overlying Gardiners proper which were deposited before the Ice crossed the Sound; deposits of ground moraine and reclassified deposition by overriding Ice, including unclassified boulders and till at Terminal Moraine culminations; and, finally, outwash of brown Wisconsin sands and gravels by modification of the surface during, and subsequent to, retreat of the Ice. All of these sediments are highly porous, including moraine material, and act as a widespread "sponge" in absorbing rainfall precipitation.

The total thickness of Post-Gardiners deposition varies extraordinarily. In the area extending from Bowery Bay to Greenpoint, the mantle of permeable brown sands and gravels is relatively thin. Occasionally, these Post-Gardiners deposits extend sufficiently below sea level to afford water yields of 100 to 200 gallons per minute. This water comes from the local catchment area and is more or less isolated from the main supply lying to the east of it. There does not seem to be any Post-Gardiners water of economic importance in Greenpoint between Newtown Creek and the East River, except that encountered near the shore lines arising from salt water infiltration.

In the balance of northwestern Queens, between Brooklyn and the edge of Flushing Meadows, most water development to date has come from Post-Gardiners gravels, with only two known wells now pumping from below the Gardiners. One of these (Durkee's) develops less than 200 gallons per minute from what is apparently Lloyds immediately over bed rock; the other is the Long Island Railroad well at Glendale, delivering upwards of 400 gallons per minute from a noticeably disturbed Lloyds formation. It is noteworthy that in drilling the Glendale well copious fresh water yield, rather high in iron, was encountered in what is evidently Jameco.

Northern Brooklyn, from Williamsburg across to the line of the Brooklyn Moraine extending eastward of Prospect Park, has its wells mostly in Post-Gardiners, except a few deeper ones scattered along and in the vicinity of Flushing Avenue. These, noticeably the Pfizer wells, reveal distinctly softer water under the Gardiners. Post-Gardiners water movement in the Brooklyn-Queens quadrangle, bounded by Queens Moraine, Flushing Meadows and Brooklyn Moraine is effected by the "Brooklyn Crater", as will presently be discussed.

The outwash gravels and sands which had developed before Ice advanced over the Island were pretty thoroughly reworked and removed by scour under the area of the first Ice encroachment. North of the Queens Moraine they are less permeable than south of it and contain boulders and boulder clay in many places. Between the Queens and Brooklyn Moraines, these outwash deposits appear to be equally permeable with overlying Wisconsin sediments providing a considerably thicker section of the Post-Gardiners water-bearing zone.

Along the East River, from Gowanus Bay to Newtown Creek, Post-Gardiners deposits rest upon Cretaceous (both reworked and undisturbed remnants) and bed rock more than they do upon Gardiners. Between the Greenpoint non-water-bearing district and the head of Gowanus Canal, the Wisconsin blanket is persistently underlain by cobbles and boulders obviously deposited when the Ice made its last invasion to the Brooklyn Moraine. Water-bearing sands, predominantly brown in color, occur under this boulder zone and apparently are ground moraine, rather than older outwash deposits. Water-bearing Post-Gardiners formations extend to the proximity of the East River shore line between Governor's Island

and Greenpoint. Salt water could enter them readily were it not for the persistent phenomenon of sealing the river's bed and shores by silts and clays.

The Brooklyn Moraine, as previously indicated, apparently rests upon a basement of early permeable outwash deposits, affording not only excellent well yields but free means for Post-Gardiners water interchange beneath it. In Queens, east of Forest Hills, it pushed over the top of the Queens Moraine and apparently spread southward of it without much disturbance of the outer-fringe deposits along the south slope of the old moraine.

The final blanketing of Post-Gardiners deposition by highly permeable brown Wisconsin sands and gravels is largely modification and outwash deposition as the Ice retreated northward. These are particularly well stratified above the northerly slopes of the moraines wherever frontal lakes formed between the retreating Ice Front and the morainal hills. Along the south moraine slopes, Wisconsin deposits spread fan-wise to form thick talus filling over the lower slopes, pitching in typical peneplain fashion. Lacustrine Wisconsin deposits between the Ice Front and the moraines apparently were carried westward of Little Neck Bay and distributed over northern Queens and Brooklyn by outlet drainage of the frontal lakes.

Taken in combination, these Post-Gardiners deposits present an Island surface of high water absorptive qualities. The Wisconsin mantle is an ideal sponge to soak up high percentages of rainfall precipitation and pass it into the permeable underlying Post-Gardiners gravels and sands. In general, the water deposits above the Gardiners aggregate the most important water-bearing horizon for industrial development in both Kings and Queens Counties.

Around the shore lines, particularly on the Atlantic side, there is practically no impediment to the diffusion of Post-Gardiners waters into the ocean. There is a certain amount of sealage created by silts along the western Brooklyn shore, from the Narrows to Greenpoint. Sealage against either diffusion or salt infiltration is provided in Greenpoint by rising Cretaceous sediments; but little appears to exist around the western end of Newtown Creek, including English Kills and Maspeth Creek. In the vicinity of Flushing and Bowery Bays, fresh water diffusion in the Post-Gardiners is apparently limited, though not prevented, by a certain amount of fine silt deposition along the shores. In fact, there seems to be some restriction against fresh water diffusion because of silting along the East River, everywhere west of Little Neck Bay. However, there is no distinctly impermeable seal along the North Shore of Queens, except that which apparently underlies the Meadows at the heads of Flushing and Little Neck Bays. In these Meadows occur characteristic soft tidal-marsh silts and clays only a few feet below the surface, which appear to exclude direct downward percolation of salt water into underlying fresh water strata. But, Post-Gardiners is exposed along the hillsides bordering the Meadow flats, from which fresh water tidal-marsh tributaries arise.

The South Shore, from the Narrows to the Borough boundary in Jamaica Bay, apparently affords no restriction whatsoever against seaward loss of fresh water. Usually, silting exists under bays and inlets, but beaches are so extensive that Post-Gardiners water generally stands about sea level in widespread shore zones. The only barrier against salt invasion is slow but continual diffusion of fresh water under the head of its higher inland static table. Any pumping, therefore, which may tend to lower water tables in Brooklyn's sandy plains eastward of the Bay Ridge Channel, will aggravate Post-Gardiners salt intrusion that has already made noticeable inroads in south Brooklyn. The bed and shore line of Jamaica Bay and its estuaries contain tidal-marsh deposits which seal the underlying permeable sands in such manner as to afford slightly better restriction against rapid salt water infusion than occurs in Brooklyn's Atlantic shore, or the barrier beach fronts. But, this does not in any way restrict seaward loss of fresh water, because thick, permeable Post-Gardiners deposits pass under Jamaica Bay and are exposed to salt water at the Rockaway beaches.

The retention of ground water storage in Post-Gardiners sediments depends upon the volume of recharge by rainfall, since seaward diffusion is purely a matter of displacement. The factor controlling fresh water loss is frictional or capillary resistance to water movement, varying with the permeability of the sediments. The Post-Gardiners underground water divide seems to run along the Queens (Ronkonkoma) Moraine, with possible local variations where permeable Wisconsin sands cover it east of Flushing Meadows. The continuity of the Queens Moraine is broken under both Flushing and Bayside Meadows, apparently due to undercaving when ice melted beneath it. There are certain indications that the Ice fingers which created Flushing and Little Neck Bays projected to the vicinity of the early Terminal Moraine.

West of Flushing Meadows and north of the Queens Moraine, Post-Gardiners water recharge is practically limited to whatever the local watershed provides. In a sense, this also holds between Flushing and Little Neck Bays, but the volume of recharge is supplemented by northward diversion of Post-Gardiners ground water from the zone between Horace Harding Boulevard and Grand Central Parkway. Therefore, in a practical sense, it seems safe to assume that all rainfall on the Brooklyn-Queens watershed, south of the Queens Moraine, diffuses southward or westward. Moreover, it seems proper that in future studies a careful distinction should be made between water tables in the Post-Gardiners and those of wells developing formations below the Gardiners' horizon.

*H.—Brooklyn Crater*

In northwest Brooklyn, adjacent to the East River, occurs a phenomenon of over-pumping, commonly termed the "Crater". It is a depression of ground water levels taking the form of a crude half-moon which swings around Wallabout estuary with one end in Williamsburg midway towards English Kills; the other near

Brooklyn Heights midway towards Gowanus Bay. Between its bluntly rounded ends or "knobs", the Crater's trough bulges eastward along an axis roughly following Atlantic Avenue and extending beyond Bedford. In the trough of the Crater, northwards of Flatbush Avenue, water levels lie as much as 40 feet below tide. Towards the East River they rise sharply, reaching sea level only a short distance back from the shore line. The contours of their rise from the trough's bulging outer curve, eastwards, are not nearly so abrupt, but apparently reach an elevation slightly above sea level after passing under the Brooklyn Moraine.

One should note, especially, the position of the semi-lunar body of the Crater within the "peninsula" formed between Gowanus Bay and English Kills, surrounded by formations seeming to be impermeable everywhere west of a line connecting the head of the Bay with the tip of the Kills. Evidently, its principal source of replenishment must be lateral draft upon the water-bearing Post-Gardiners beds between the two moraines. The Crater is obviously a giant "cone of depression", created by excessive industrial pumping in the district, which has deepened and projected itself eastward as water demand compelled diversion from more remote Post-Gardiners sources.

The proximity of the inner curve of the Crater to the East River north of Flushing Avenue, obviates doubt about sealage against free salt water percolation, for salinity of Crater water has shown little or no tendency to increase proportionately with the dropping ground water table. This cannot be laid entirely to silting of the River's bed, for numerous wells along the Williamsburg shore line, in some of which the water table stands below River level, have yielded salt water for many years. There must be a further zone of impermeable sediments between these wells and the Crater proper which restricts salt water flow into the Crater's void. The trough of the assumed old southward course of the East River may be the basis of this impermeability. Apparently, under the Navy Yard and northward, blue clays and other fine sediments cover rock to about sea level. There appear to be extensive fine deposits all around the Wallabout Basin that might have precipitated in slack-water. These gradually merged northward, under the extreme western part of Williamsburg, into impermeable strata that appear to have been deposited along the shore line of the old river course.

Westward from the Navy Yard, shore line silting since the diversion of the East River apparently affords the principal seal against salt. However, the wells in Columbia Heights are highly saline. In fact, all Post-Gardiners water in the Gowanus Canal-Buttermilk Channel peninsula, south of Columbia Heights, is definitely salt. All of this northwestern corner of Brooklyn between Wallabout and Gowanus consists of highly disturbed finer elements intermingled with cobbles, boulders and ground moraine, as has been previously noted. Therefore, despite occasional lenses or streaks of water-bearing Post-Gardiners found in it, the general mass below sea level appears to retard sea water percolation towards the

Crater. The southwestern "knob" of the Crater projects slightly into this salt zone near the head of Gowanus Canal, with its deeper part protected against salt invasion by thick silting in all directons around the head of the Canal.

Fairly fresh water is reported immediately south of the Navy Yard, everywhere east of Bridge Street, in permeable Post-Gardiners gravel and sand containing many boulders. Obviously, there must be a definite seal between this and Columbia Heights since it lies between the Heights and the trough of the Crater. It would appear axiomatic that the very existence of the Crater is, in itself, excellent proof of generally effective shore line sealage against salt intrusion everywhere between the head of Gowanus Canal and the tip of English Kills.

# IV

## SUMMARY

In closing it may be well to review economically important features of the various water-bearing strata. Also, to roughly outline the areas in which they may be encountered. And finally, to give a resumé of the highlights of indicated contacts or association between permeable and impermeable formations which may effect water interchange between them.

Lloyds is confined to Queens and a Brooklyn zone along the shore line between Gravesend Bay and the Borough line at Woodhaven. Its northern Queens limit is a weaving or ''feathering'' line of bed rock overlap extending from about El. -200 under Whitestone to El. -250 more or less in the vicinity of Maspeth. Here, it makes a nearly right-angle turn, crossing the Sound River Valley to the vicinity of Ridgewood. The Valley apparently cut through the Lloyds horizon before it reached bed rock in its travel towards Flatbush. Whether Lloyds gravels lie directly in contact with Jameco in the Valley bottom cannot be stated, though there are indicated possibilities this may be so. Southwest from Ridgewood the Lloyds terminus diagonals under the Brooklyn Basin towards Gravesend Bay apparently following an irregular line between rock contours -400 feet and -500 feet. Here also are suspicious indications Lloyds may be closely enough in contact with Jameco for water interchange between them. Presumably, therefore, Lloyds underlies Queens everywhere southwards of its rising line of bed rock contact between El. -250 near Maspeth and approximately -200 feet in Whitestone. In Brooklyn, it should be encountered wherever bed rock is more than 450 feet below present sea level.

Magothy Sand is seldom found in Brooklyn, except possibly in the Barren Island district. It is confined to Queens southwards from the Cretaceous scarp forming the left Valley wall. The Magothy horizon obviously outcrops along this scarp and presumably may be in contact with Jameco valley-filling. Therefore, water interchange may exist between Magothy and Jameco, provided Ice thrust or Valley wall sloughing has not closed this indicated direct contact. Magothy Sands, moreover, extend under Queens to the Nassau line, apparently becoming more continuous as they progress eastward. It is conceivable that they may lie in direct contact with Jameco filling of the Valley indicated to underlie western Nassau. Therefore, it is possible, though by no means assured, that the Magothy horizon may form rather far reaching sources of water interconnection between Nassau aquifers and those of the Sound River Valley.

Jameco covers practically all of Brooklyn and Queens southeast of its mergence with Gardiners, reworked Cretaceous or other fine right Valley wall sediments. Along the harbor line, from Gowanus Bay to the Narrows, Jameco gravels may have been rendered

impermeable by intermixing of silts during the filling of the Hudson canyon. It is even possible that admixture of fine sediments from outpouring Hudson discharge may affect the Jameco's water-bearing characteristics in all the area between Gowanus and Gravesend Bays. The top of the Jameco horizon, between English Kills and Gowanus Bay, varies between 125 feet and 150 feet below sea level, but side-wash or reworking in this zone has evidently carried fine sediments considerably south and eastward in places. Around the Gowanus estuary, water-bearing Jameco gravels are usually absent down to 200 feet below sea level. Similarly, there is an area surrounding English Kills and the end of Newtown Creek, where typical Jameco gravels do not show at depths as much as -250 feet. Through northwestern Queens, Jameco deposits have been disturbed by Ice movement to the Queens Moraine; therefore, they frequently show little water-bearing value north of the Moraine line. South of the Moraine line Jameco appears to be a generally good aquifer throughout both Queens and Brooklyn, except for possible thinner portions immediately over higher parts of the old Cretaceous land surface in Queens. In general, Jameco seems to be well sealed against salt contamination everywhere except across the south end of the Brooklyn Basin, where Gardiners blanketing is only doubtfully indicated. The method of sealage across Jameco emergence into the Sound at the northern end of the Valley is unknown and therefore must be ascribed to some phenomenon of Ice ploughing. Possibly, the projecting bottom Ice which formed Little Neck Bay, carried to the line of the Queens Moraine at Alley Pond. The nose of this Ice, acting in the manner of a ploughshare, may have overturned clays from the Valley bottom into overlying Jameco gravels.

Gardiners covers practically all of both Boroughs southeast of an original shore line overlap, ranging from about -100 feet at Gowanus Bay, to -80 feet more or less in Whitestone. The top of Gardiners sediments, originally deposited in the area between Wallabout Basin and Whitestone Point, may have stood only 50 feet or 60 feet below present sea level in its closing phases of deposition as the Ice Front neared the Sound. Gardiners appears to merge into reworked or other fine side-wall deposits everywhere along the right Valley wall, between Willets Point and Gowanus Bay. South of lat. 40° 40′ Gardiners pitches from an average elevation of -100 feet to -200 feet under the Rockaways. Westward of Rockaway Inlet, it drops, in the Brooklyn Basin area, to a level of -250 feet more or less, under Coney Island. Nothing very definite is known about the position of the Gardiners in western Brooklyn, between McDonald Avenue and New York Bay. Between Prospect Park and Gowanus Bay, data from scattering wells, including a number at Bush Terminal, indicate its top to lie 90 feet to 100 feet below sea level. North of the Queens Moraine, Gardiners is too disrupted and folded from Ice scour to determine much about either its elevation or continuity. However, in the Sound River Valley area, between Bayside and Flushing Meadows, there are indicated possibilities that the Gardiners seal may be broken in

places to permit downward percolation of surficial waters into the Jameco. In general, the widespread indications of its unbroken sealing horizon, north of lat. 40° 40′, continue south of this parallel to the Atlantic shore, except for the questionable area across the outlet of the Brooklyn Basin. Whether Gardiners extends sufficiently seaward of the South Shore to completely blanket underlying Jameco against salt contamination is, of course, undeterminable. Conceivably, the deposition of Gardiners, beyond the Island's present South Shore, may merge into fine sediments far beneath the present ocean bed, or with silts carried in by the Hudson as the sea encroached its canyon, before the Island area sank below tide.

Post-Gardiners sediments form a highly permeable blanket over both Counties. They are too thin for great water yield in Greenpoint, parts of Long Island City and Astoria. In fact, their economic worth is generally limited between Flushing Bay and Newtown Creek, north of the Queens Moraine. Between the two moraines, they form a thick, generally permeable belt leading directly into the elevated water table of piled-up Wisconsin deposits which have created the highest surface of the two Counties. Flushing Meadows breaks through this belt at the western edge of the highland plateau, diverting some surficial water into the Bay. Marsh deposits beneath the Meadows protect permeable underlying Post-Gardiners against downward salt contamination in the Meadows proper.

The water table divide in the plateau-like highland north of Grand Central Parkway, correlates with the Brooklyn Moraine line, yet the underground water divide is more likely over the line of the Queens Moraine, rather than along the crest of underground water contours. The major part of rainfall absorbed by Post-Gardiners sediments in Kings and Queens, aside from pumping draft, diffuses seaward around the shore line, rather than into formations below the Gardiners horizon. For this reason, it seems advisable to encourage industrial development from Post-Gardiners rather than underlying aquifers, wherever feasible. Salting of Post-Gardiners water in southern Brooklyn seems inevitable, due to paucity of sealing around the southern shore line, below Gowanus Bay. The former prevalence of fresh water in Post-Gardiners sands and gravels was caused by steady seaward diffusion from piled-up ground water accumulation in the more elevated inland. Re-establishment of fresh water domination over salt seems futile due to the increasing number of industrial wells.

# V

## CONCLUSIONS

Certain conclusions arise from comparative study of existing pumping conditions. For instance, Lloyds under Brooklyn has shown no indication of developing salt water and its water still rises above tide under static head. Yet, the Queensborough Gas and Electric well at Rockaway Beach has a notable chlorine increase. This may be localized contamination from deterioration of old well casings, instead of general salt infiltration along the Lloyds outcrop. In any case, it demands some remedial procedure, at least compulsory plugging of old wells to prevent downward percolation of salt water through clays they penetrate.

Development of the Jameco, particularly in the Sound River and Brooklyn Basin areas, should be closely regulated against lowering of the Jameco water table. It seems pertinent, to provide information for proper State control, that special attention be given to recording the water tables in the Jameco separately from those of Post-Gardiners aquifers. Data now available indicate that water tables in Jameco, Magothy Sand and Lloyds are related, if not actually connected, in portions of Kings and Queens. Those of the Post-Gardiners evidently are not directly related to them.

Apparently, the total rainfall absorbed by the surface of the two Counties still exceeds well draft in the Post-Gardiners despite heavy over-pumpage in the Crater. Obviously, water withdrawal from above the Gardiners in Brooklyn is pulling upon storage in Queens, and this in turn may be exercising an influence on the westward diffusion of Post-Gardiners storage in Nassau. However, regardless of any overdraft in Brooklyn, some of Nassau's Post-Gardiners water will continue to pass into Queens pursuing its normal lateral diffusion under static pressure from its higher inland water levels. Therefore, it is better to utilize Post-Gardiners water for industrial cooling wherever possible, rather than to pump from the deeper underground resources. The return of water into the Post-Gardiners by diffusing pits appears to be the most practical retardant against salt water encroachment in both Brooklyn and Queens south of lat. 40° 40′. This of course offers no amelioration of the increasing ground water temperature that has been evident in the Crater. A program of restoring Crater depletion by recharging from the City mains whenever upstate storage is wasting over spillways, may possibly alleviate the indicated menace of the Crater. In fact, any program which might bring about utilization of the City's upstate supply whenever freshets overflow the dams, is worthy of consideration.

It likewise seems important to continue studies of industrial disposal of cooling water that is uncontaminated. Even though there be prescriptive rights for pumping cooling water from old wells, the time may come when conservation may compel returning

it to the ground. It is even possible that extension of diffusing pit water disposal in various quarters may in part restore the old cycle of seaward diffusion through Post-Gardiners formation and minimize ground water temperature rise.

Test borings are urgently needed to provide more accurate data in certain areas. These should be made under specifications and supervision which will develop the utmost information from them. The determination of each successive test location should be based upon information gained in preceding borings. At least two are needed along the Coney Island Peninsula, also others running from Bay Ridge across the southern part of Brooklyn, to determine the character of Jameco sediments, the possible location of the edge of the Hudson's rock canyon and the Lloyds terminus over the rising bed rock. Furthermore, drilling along the Sound River Valley's Cretaceous scarp, accompanied by a few strategic offset tests in the Valley proper, will clarify obscurities which now severely limit the scope of our information.

# VI

## LOCAL PROVINCES IN KINGS AND QUEENS

The underground structure of both Counties divides into provinces that roughly segregate as three sections of each County. These arise from variations such as: absence of important formations, predominant thickness of certain strata, or alterations in water-bearing characteristics by reason of Ice reworking. These localized features will be discussed under the following headings:

### Kings County

*Section I.* All of Brooklyn south of parallel 40° 40′ lat. a line running from the mouth of Gowanus Bay, bisecting Prospect Park, to the Borough line near Linden Boulevard.

*Section II.* The balance of Brooklyn north of this parallel, except a roughly triangular northwest sector between English Kills and Wallabout Basin.

*Section III.* The district bounded by East River and Newtown Creek lying northwest of an arbitrary line running from the intersection of Flushing and Clinton to the tip of English Kills.

### Queens County

*Section I.* All of Queens south of the line of Interborough and Grand Central Parkways.

*Section II.* The balance of Queens north of the Parkways, except the extreme northwestern sector between Newtown Creek and Flushing Bay.

*Section III.* The district bounded by Newtown Creek, East River and Flushing Bay, northwest of an arbitrary line running from the tip of English Kills to the intersection of Northern Boulevard and Grand Central Parkway.

## TABULATION OF WELL DATA

Accompanying each section are tables showing the depths of important geologic horizons below mean tide. Minus signs are omitted, as all figures except surface elevations represent distances below sea level. Occasionally, when geologic horizons are above sea level, this is indicated by plus (+) marks. An effort is made to tabulate well locations in such order as to progressively

disclose variable elevations of the formations in nearby wells. The following key explains the column headings:

El. —Land surface elevation above mean sea level.

Dph.—Depth of well.

P. G.—Bottom of formations deposited subsequently to Gardiners. Figures do not always represent the top of the Gardiners, particularly in Sections II–III of both Counties where Gardiners may be absent or too badly reworked for recording.

P. J.—Bottom of formations deposited subsequently to Jameco filling of valleys.

P. C.—Top of old Cretaceous land surface. In Sections I–II Queens, where ice thrust elevated the old surface, occur zones of intermingled Cretaceous and Jameco.

U. P.—Horizon of irregular pinkish or reddish clays and occasional fine sands of Cretaceous deposition believed to have originated from Triassic rocks in Connecticut, which occasionally overlie the Magothy Sand.

Mag.—Magothy aquifer or water-bearing horizon.

L. P.—Horizon of salmon-pink or mottled Cretaceous clay deposited above the Lloyds.

Lds. —Lloyds water-bearing sand.

Rock—Bed Rock

Generally figures represent the indicated top of marker formations.

## SECTION I—KINGS COUNTY

This section includes approximately 70% of Brooklyn from the shore line of upper New York bay below Gowanus, to the eastern Borough boundary south of Linden Boulevard. The Brooklyn Moraine stretches across it from Prospect Park to the Narrows, paralleling and partly westward of Fort Hamilton Parkway. The western sides of the moraine hills are relatively steep, with a narrow belt of flat shore line along the Bay. Their eastern slopes are more gentle. Wisconsin sands form talus deposits that thicken the Post-Gardiners across the wide plain stretching towards sandy shores between Gravesend and Jamaica Bays.

Bed rock underlying this section pitches from a depth of approximately –200 feet in the vicinity of Gowanus Bay to a maximum of about –1100 feet at Barren Island. The rock contours appear to be quite regular in their pitch from northwest to southeast. In the extreme southwestern corner of Flatbush occurs the only indicated deviation from normal bed rock pitch where a Flatbush Water Company test well at Newkirk and Nostrand penetrated over 100 feet of gray sandstone (?) at its bottom without encounter-

ing normal bed rock. This lone datum may indicate a pitching rock trough into the Hudson canyon at the mouth of the Sound River Valley. It is mentioned purely as a matter of record since there are no reliable data verifying the existence of such a trough.

The floor of the Brooklyn Basin underlies practically all of Section I between the Upper Bay and Vansinderen Avenue. In the east it covers Cretaceous land surface averaging about 400 feet below tide, and west of this, the rising bed rock above contour El. –400. The Brooklyn Basin may extend beyond Vansinderen Avenue, but evidently the left Valley wall Cretaceous scarp projects into the extreme eastern part of Brooklyn between Highland Park and Canarsie. There are no indications of Magothy Sand under Section I, except possibly what may occur in about 700 feet of Cretaceous sediments underlying the Barren Island sector. Lloyds may be encountered wherever bed rock is more than 450 feet below tide. Its fringe, along the hypothetical terminus on the rising bed rock, may have been removed during the cutting of the Sound River Valley however. Such wells as penetrate the Lloyds develop potable water which rises above sea level. This indicates relatively free passage of water through the Lloyds horizon from remote areas where elevated water tables prevail.

Jameco constitutes the most important potable water-bearing horizon in Section I. Very little is known of the character of Jameco sediments west of McDonald Avenue, yet it appears reasonable that some sort of sealage against salt exists in the area between Gravesend and Gowanus Bays. This may consist of Hudson silting mixed with Jameco deposits, or other impermeability arising from eddy phenomena at the fork of the Hudson and Sound Rivers.

In the area bounded by Prospect Park, Greenwood Cemetery and Gowanus Bay, wells have penetrated deep enough to reach the Jameco horizon. These indicate, in the general vicinity of the Bush Terminal, that Gardiners stands approximately at its "normal" position. However, there are also indications that it may be broken or disturbed, because salt water is reported both above and below the Gardiners horizon, with less salt below it than above. There are no data on Gardiners or Jameco between Eighth Avenue and Gowanus Bay north of Bush Terminal wells. One can only interpolate underground conditions in this area from the logs of wells in both Sections I and II surrounding it. Presumably, both Gardiners and Jameco are vague and much disturbed. Moreover, formations to bed rock appear open to direct salt water seepage. The presumable "dike" of impermeable Jameco paralleling Gowanus Canal in Section II may extend southward and merge into generally impermeable Jameco deposits in the vicinity of Greenwood Cemetery. Reports of variable salinity in wells surrounding the Gowanus estuary are highly conflicting. There is evidently a certain amount of fresh water diffusion over the "dike" from eastward Post-Gardiners deposits to account for wide saline variation in wells adjacent to the

Gowanus estuary. However, this does not account for the decreased saline content below the Gardiners horizon found in recent Bush Terminal wells, and for indications that Jameco southward from the Terminal contains water low in salt. Apparently, there must be movement of fresh water in the Jameco towards the shore lines somewhere below Greenwood Cemetery, if meager reports of fresh water in deep wells south of Bush Terminal are reliable.

Fresh water underlies the Brooklyn Moraine in what appear to be outwash sands and gravels between the bottom of the Moraine and the Gardiners. There is also certain evidence that Post-Gardiners water tables in places under the Moraine are slightly elevated, possibly because less permeable moraine sediments retain water storage better than adjacent sands and gravels. The area east of the moraine slopes, with its thick covering of outwash Wisconsin sands, is highly vulnerable to salt intrusion. The only protection it has is a limited amount of fresh water diffusion towards the shore lines, and most of this seems to originate from local rainfall.

The pumping operations of the Flatbush Water Company have developed a noteworthy distinction between water tables above and below the Gardiners. Apparently, the volume of their water withdrawal results in a rather sluggish rate of water level return whenever pumping is stopped at any of their stations. Post-Gardiners water levels in the north, particularly the northeast corner, show the effect of the Crater. Below Prospect Park and generally in southern Flatbush, they are higher. Jameco water levels on the other hand seem rather constant, but considerably below those of the Post-Gardiners. Yet, scattering evidence, whereever pumping has been discontinued for protracted intervals, reveals a tendency of water levels, either above or below the Gardiners, to return approximately to sea level where they were recorded some years back. It would appear then, that the Company's operations now create what might be termed an ephemeral cone of depression, holding the Jameco water table approximately 19 feet below tide and the Post-Gardiners in the vicinity of 9 feet, except in the northern part adjacent to the eastward bulge of the Crater. These may be revelations from more careful observations in recent years, or of increased Jameco draft since the drilling of deeper wells at certain pumping stations.

## Section I—Kings County

In the area west of McDonald Avenue and Prospect Park such well data as can be found yield only doubtful information of the position of the Gardiners and Jameco formations. The following tabulation of these wells lists those lying between Prospect Park, Greenwood Cemetery and Gowanus Bay first, following with those in the Terminal Moraine south of Greenwood Cemetery in order to show the need of additional data in this relatively large "terra incognito."

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| Ky-45...... | 33-Marginal...... | 0′ | 100′ | (?) | .... | .... | .... | 100′ reworked formations. |
| K-163...... | 32 nr. 3rd........ | 10′ (?) | 91′ | (?) | .... | .... | .... | Very salt at 81′. |
| K-163...... | 39 nr. 2nd........ | 7′ (?) | 205′ | 81′ | 88′ | .... | .... | Less salt below 88′. |
| K-165...... | 136 41st.......... | 15′ (?) | 93′ | (?) | .... | .... | .... | Very salt water in gr. moraine. |
| K-165...... | 39 nr. 1st......... | 6′ | 212′ | 95′ | 163′ | .... | .... | Salt above rock. |
| K-166...... | 42-1st........... | 17′ | 238′ | (?) | (?) | .... | 221′ | Mixture Jam. and P. G. Waters not excessively salt. |
| K-8...... | 18 nr. 8th........ | 166′ | 198′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| K-155...... | 14-Pros. Pk. W... | 150′ | 202′ | (?) | .... | .... | .... | Outwash P. G. under maraine. |
| K-251...... | 43-5th........... | 110′ | 205′ | (?) | .... | .... | .... | Outwash P. G. under moraine. |
| K-439...... | 58-1st........... | 4′ | 100′ | (?) | .... | .... | .... | P. G. sealing indicated. |
| K-245...... | 46-8th........... | 131′ | 174′ | (?) | .... | .... | .... | Outwash P. G. under moraine. |
| Ky-52...... | 74-4th........... | 55′ (?) | 141′ | 86′ (?) | .... | .... | .... | Outwash P. G. under moraine. Gard. elevated. |
| K-173...... | 72-Ridge Bd...... | 71′ | 170′ | (?) | .... | .... | .... | Used for drinking water. |
| K-308...... | 67 nr. Ft. Ham.... | 74′ | 147′ | (?) | .... | .... | .... | Outwash P. G. under moraine. |
| K-316...... | 72-5th........... | 60′ | 145′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| K-316...... | 74-5th........... | 65′ | 124′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| K-244...... | 60-8th........... | 70′ | 118′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| K-576...... | 92-4th........... | 83′ (?) | 130′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| K-319...... | 82 nr. 6th........ | 80′ (?) | 435′ | (?) | (?) | (?) | 269′ (?) | Driller claims 59′ rock. |
| K-319...... | 525 86th......... | 80′ (?) | 162′ | (?) | .... | .... | .... | Outwash P. G. under moraine. |
| Ky-53...... | 74-11th.......... | 90′ (?) | 120′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| Ky-51...... | 40-6th........... | 130′ | 89′ | .... | .... | .... | .... | Not through Terminal moraine. |
| Ky-54...... | Dyker Pk......... | 24′ | 60′ | .... | .... | .... | .... | Not through Terminal moraine. |
| Ky-55...... | Ft. Laf........... | 5′ | 53′ | .... | .... | .... | .... | No shore seal. |
| Ky-56...... | Sh. Rd-3rd....... | 58′ | 130′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | 96-3rd........... | 62′ | 105′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | Nrs. nr. Bklyn.... | 0′ | 117′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | Nrs. nr. Bklyn.... | 0′ | 115′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | Nrs. nr. Bklyn.... | 0′ | 114′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | Nrs. nr. Bklyn.... | 0′ | 127′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | Nrs. nr. Bklyn.... | 0′ | 120′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | Nrs. nr. Bklyn.... | 0′ | 126′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-56...... | Nrs. nr. Bklyn.... | 0′ | 122′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 119′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 118′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 120′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 119′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 113′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 114′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 118′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 121′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 125′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 136′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Nrs. nr. S. I...... | 0′ | 130′ | (?) | .... | .... | .... | P. G. seal indicated. |
| Ky-57...... | Wad. Rd. S. I..... | 52′ | 142′ | (?) | .... | .... | .... | P. G. seal indicated. |

The following wells lie east of the Terminal Moraine and south of Flatbush.

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| K-311A.... | 65-22nd......... | 25′ | 153′ | (?) | .... | .... | .... | All Wisconsin. |
| K-174...... | E. 3-Av. P....... | 29′ | 110′ | .... | .... | .... | .... | All Wisconsin. |
| K-304...... | E. 35-Kgs. Hy.... | 25′ | 142′ | .... | .... | .... | .... | All Wisconsin. |
| K-328...... | 86 nr. 20th....... | 30′ | 112′ | .... | .... | .... | .... | All Wisconsin. |
| K-201...... | 46-Ave. N........ | 17′ | 82′ | .... | .... | .... | .... | All Wisconsin. |
| K-464...... | V— Mill......... | 5′ (?) | 494′ | 245′ (?) | 263′ (?) | 395′ | .... | Lds. 443-489 'Salt under possible P. G. at 159′. |
| K-577...... | 54-Ave U........ | 6′ (?) | 150′ | (?) | .... | .... | .... | All Wisconsin. |
| K-1........ | 21-Neptune....... | 5′ | 750′ | 269′ (?) | 277′ | 393′ | 673′ | Pink C at 423′ Lds. or Mag. at 471′. Pink 520′. |
| K-318...... | 17-Surf.......... | 7′ | 135′ | .... | .... | .... | .... | All Wisconsin. |
| K-205...... | Br. Beach........ | 5′ (?) | 518′ | 195′ | 215′ (?) | 356′ (?) | .... | Lds. app. 462′. |
| K-203...... | Barren Is......... | 5′ | 724′ | 213′ (?) | 225′ (?) | (?) | .... | Very poor log Lds. app. 707′. |
| K-203...... | Barren Is......... | 5′ (?) | 740′ | (?) | 255′ (?) | (?) | .... | Lds. app. 685-735′. |

The following wells are in Flatbush, or east of it to the Borough line.

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| K-323...... | 333 Rogers....... | 85′ | 139′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| K-526...... | Franklin-Sull..... | 82′ | 371′ | 140′ | 211′ | .... | 289′ | Jam. st. 21′. |
| K-517...... | 311 Empire Bd.... | 79′ | 303′ | 109′ | 164′ | .... | .... | Jam. st. 21′. |
| K-519...... | Troy-Rutland.... | 29′ | 352′ | 131′ | 157′ | .... | .... | Jam. st. 19′. |
| K-507...... | Troy-Rutland..... | 31′ | 100′ | (?) | .... | .... | .... | P. G. st. 20′. |
| K-520...... | 98th-Rutland..... | 41′ | 419′ | 106′ | 132′ | .... | 388′ (?) | Jam. st. 17′. |
| K-516...... | 98th-Rutland..... | 42′ | 106′ | (?) | .... | .... | .... | P. G. st. 21′. |
| K-149...... | Dumon-Powell.... | 36′ | 160′ | 104′ (?) | .... | .... | .... | In Jam. at 124′. (?) |
| K-528...... | 710 Parkside...... | 61′ | 372′ | 172′ | 195′ | .... | 296′ | Jam. st. 20′. |
| K-525...... | 363 Dahill........ | 46′ | 405′ | 174′ | 249′ | .... | .... | Jam. st. 1′ after 12 hours shut-down. |
| K-501...... | 363 Dahill........ | 47′ | 112′ | (?) | .... | .... | .... | Outwash P. G. st. under moraine 6′. |
| Ky-48...... | Vansinderen-New-port........... | 25′ | 451′ | 101′ (?) | 120′ | .... | .... | Gard. possibly absent. |
| K-538...... | New Lots — Foun-tain........... | 10′ | 164′ | 103′ | 108′ | .... | .... | Not through Jam. 154′. |
| K-538...... | Pump Sta........ | 10′ | 172′ | 107′ | 112′ | .... | .... | Not through Jam. 162′. |
| K-538...... | Pump Sta........ | 10′ | 151′ | 88′ (?) | 97′ (?) | .... | .... | Not through Jam. 141′. |
| Ky-49...... | Vienna-Lind...... | 5′ | 434′ | 105′ | 151′ | 284′ | .... | Possi. Mag. 408′. |
| K-508...... | 8th-Caton........ | 50′ | 120′ | .... | .... | .... | .... | Outwash P. G. st. under moraine 14′. |
| K-522...... | 1424 Erasmus..... | 50′ | 300′ | 170′ | 210′ | .... | .... | Combined P. G. Jam. st. 16′. |
| K-527...... | 1424 Erasmus..... | 50′ | 145′ | .... | .... | .... | .... | Outwash P. G. st. under moraine 17′. |
| K-510...... | 36 Louisa......... | 63′ | 120′ | (?) | .... | .... | .... | Outwash P. G. st. under moraine 9′. |
| K-503...... | 401 McDonald.... | 63′ | 138′ | (?) | .... | .... | .... | Outwash P. G. st. under moraine 10′. |
| K-503...... | 401 McDonald.... | 63′ | 320′ | 164′ (?) | 184′ (?) | .... | .... | Gard. appears disturbed. |
| K-529...... | 401 McDonald.... | 63′ | 220′ | 157′ (?) | .... | .... | .... | Outwash P. G. st. under moraine 10′. |
| K-512...... | 520 Coney Is..... | 48′ | 106′ | (?) | .... | .... | .... | Outwash P. G. st. under moraine 14′. |
| K-524...... | Utica-Lenox...... | 33′ | 390′ | (?) | 197′ | .... | 349′ | Jam. st. 17′. |
| K-506...... | Utica-Lenox...... | 33′ | 113′ | .... | .... | .... | .... | P. G. st. 19′. |
| K-530...... | 912 Cortelyu...... | 33′ | 160′ | (?) | .... | .... | .... | P. G. st. 9′. |
| K-521...... | Utica-Bev........ | 34′ | 430′ | 179′ | 323′ | .... | .... | Jam. st. 1′ (?) |
| K-502...... | Newk-Nost....... | 11′ | 106′ | .... | .... | .... | .... | P. G. st. 11′. |
| K-500B.... | Foster-31st....... | 16′ (?) | 465′ | 141′ | 179′ | .... | 404′ | Test well. |
| K-500...... | Foster-N. Y...... | 17′ | 469′ | 150′ | 273′ | .... | 416′ | P. G. st. 9′. |
| K-515...... | Foster-38th....... | 17′ | 345′ | 149′ | 183′ | .... | .... | St. unrecorded. |
| K-504...... | Foster-Alb....... | 20′ | 109′ | .... | .... | .... | .... | P. G. st. 9′. |
| K-518...... | Foster-Alb....... | 13′ | 330′ | 157′ | 184′ | .... | .... | St. unavailable. |
| K-511...... | Foster-Alb....... | 12′ | 93′ | .... | .... | .... | .... | P. G. st. 9′. |
| K-514...... | Utica-Ave. D..... | 26′ | 100′ | .... | .... | .... | .... | P. G. st. 8′. |
| K-514...... | Utica-Ave. D..... | 26′ | 560′ | 149′ | 167′ | .... | 431′ (?) | 103′ at bottom not normal bed rock. |
| K-303...... | 1469 Utica........ | 14′ (?) | 118′ | (?) | .... | .... | .... | P. G. st. 7′. |
| K-373...... | 83 Canarsie Lane.. | 18′ (?) | 168′ | (?) | .... | .... | .... | No Gard. @ 150′. |
| K-537...... | Canarsie.......... | 7′ | 213′ | 152′ (?) | 166′ | .... | .... | In Jam. @ 206′. |
| K-537...... | Canarsie......... | 7′ | 213′ | (?) | 176′ | .... | .... | In Jam. @ 206′. |
| K-513...... | McDonald-Av. F.. | 53′ | 105′ | (?) | .... | .... | .... | Outwash P. G. st. under moraine 2′ after 16 hour shutdown. |
| K-523...... | Newk-Nost....... | 47′ | 535′ | 208′ | 248′ | .... | 385′ (?) | Outwash P. G. st. under moraine 3′ after down 67 days. Bottom 104′, not normal bed rock. |

## SECTION II—KINGS COUNTY

This section covers that part of Brooklyn north of lat. 40° 40′ where Jameco valley-filling sediments are liable to be found. The Brooklyn Moraine stretches across it from Prospect Park to the Cemetery of Evergreens. The juncture of Sound River Valley proper with the Brooklyn Basin also occurs under Section II somewhere between East New York and Prospect Park. Moreover the major part of the Crater underlies this section, projecting under the Terminal Moraine to the east of Prospect Park. In general, Section II presents a cross-section from wall to wall of the Sound River Valley that reveals its typical structural features. The merging of reworked Cretaceous sediments into Jameco along the right Valley wall occurs somewhere east of the line of Third Avenue projected northward, followed by full development of valley-filling and Post-Gardiners sediments across the Valley's bed rock basement to where the Cretaceous scarp of the left wall is encountered south of Highland Park.

Bed rock pitches from a depth of less than —80 feet in the vicinity of East River and Wallabout Basin to nearly —800 feet at the extreme southeast corner of the section. In the vicinity of the East River, the bed rock surface is quite irregular, but below contour —100 feet it takes on the same regularity of pitch generally noted elsewhere. There are two deviations in normal bed rock gradients, the more important one lying east of Brooklyn Navy Yard in the form of a rock trough, representing a possible southward course of the East River when it was tributary to the Sound River Valley. The other is at the tip of Newtown Creek along the Queens boundary, indicating the possible course of another tributary to the East River.

Neither Lloyds nor Magothy sands have been encountered anywhere in Section II, but it is probable they would be located by drilling deep wells to rock in the extreme east sector near the Queens line. As previously indicated, it is probable both Lloyds and Magothy outcrop, and even possibly lie in contact with Jameco gravels along the Cretaceous scarp south of Highland Park.

Although there are evidently thick water-bearing Jameco sediments under a large part of Section II south and east of Flushing Avenue, by far the greater development is from Post-Gardiners. These are so thick and permeable between Flushing Avenue and the Brooklyn Moraine that drilling below the Gardiners horizon has not been necessary. In the west, above rock contour El. —150, water development is confined solely to Post-Gardiners, with water-bearing Jameco gravels disappearing along a line roughly parallel to Third Avenue.

## Section II—Kings County

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| Ky-14...... | John–Jay......... | 7′ | 800′ | (?) | .... | .... | 90′ | Reworked P. G. |
| K-14....... | Bridge–John...... | 13′ | 126′ | (?) | .... | .... | 93′ | Reworked P. J. |
| K-14....... | Bridge–Front..... | 34′ | 135′ | (?) | .... | .... | 80′ | Reworked P. G. |
| K-13....... | Brdg–Tallman.... | 44′ | 144′ | (?) | .... | .... | 76′ | Reworked P. G. |
| K-73....... | Prospect–Jay..... | 57′ | 141′ | (?) | .... | .... | 72′ | Reworked P. G. |
| Ky-23...... | Sands–Bridge..... | 51′ | 151′ | (?) | .... | .... | 59′ | Reworked P. G. |
| Ky-23...... | High–Bridge...... | 56′ | 139′ | (?) | .... | .... | 62′ | Reworked P. G. |
| Ky-23...... | Conc–Flatbsh..... | 49′ | 130′ | (?) | .... | .... | 60′ | Reworked P. G. |
| Ky-15...... | Wash.–Mhn. Br... | 0′ | 108′ | 98′ | .... | .... | 98′ | Reworked P. J. Seal indicated. |
| Ky-16...... | Water–Dock...... | 4′ | 100′ | (?) | .... | .... | 85′ | Reworked P. G. Seal indicated. |
| Ky-16...... | Water–Dock...... | 5′ | 104′ | 98′ | .... | .... | 98′ | Reworked P. J. Seal indicated. |
| Ky-17...... | Popl–W. PH. L... | 0′ | 126′ | 97′ | .... | .... | 97′ | Reworked P. J. Seal indicated. |
| Ky-18...... | Cranberry........ | 0′ | 111′ | 99′ | .... | .... | 99′ | Classified P. J. Seal indicated. |
| Ky-18...... | Cranberry........ | 0′ | 117′ | 107′ | .... | .... | 107′ | Reworked P. J. Seal indicated. |
| Ky-18...... | Cranberry........ | 0′ | 115′ | 98′ | (?) | .... | .... | Gard. in place. |
| Ky-20...... | Pineapple......... | 0′ | 98′ | (?) | .... | .... | (?) | Reworked P. J. Sea lindicated. |
| Ky-20...... | Clark............ | 0′ | 94′ | (?) | .... | .... | 91′ | Reworked P. G. Seal indicated. |
| Ky-22...... | Monta–W. PH. L.. | 0′ | 86′ | (?) | .... | .... | .... | Reworked P. G. Seal indicated. |
| Ky-22...... | Montague........ | 0′ | 91′ | (?) | .... | .... | 73′ | Reworked P. G. Seal indicated. |
| Ky-22...... | Montague........ | 0′ | 64′ | .... | .... | .... | (?) | Seal indicated 16′ disintr. R. |
| K-388...... | Col. Hts.–Cran.... | 67′ | 120′ | (?) | .... | .... | .... | Reworked P. G. Seal indicated. |
| K-111...... | 73 Middaugh..... | 59′ | 100′ | (?) | .... | .... | .... | Reworked P. G. |
| K-111...... | Henry–Cranb..... | 64′ | 90′ | (?) | .... | .... | .... | Reworked P. G. Seal indicated. |
| K-111...... | Hicks–Cranb...... | 60′ | 103′ | (?) | .... | .... | .... | Reworked P. G. |
| K-15....... | Hudsn. opp. Pk... | 15′ | 114′ | 91′ | .... | .... | .... | Reworked P. G· Seal indicated. |
| Ky-24...... | BH. L. @ Joral... | 0′ | 98′ | (?) | .... | .... | .... | Reworked P. J. Seal indicated. |
| Ky-25...... | BH. L. @ Atlan... | 0′ | 89′ | (?) | .... | .... | .... | Reworked P. G. Seal indicated. |
| Ky-25...... | Atl. nr. middle of river........... | 0′ | 93′ | (?) | .... | .... | .... | Reworked P. J. Seal indicated. |
| Ky-19...... | BH. L. @ Clark... | 0′ | 92′ | (?) | .... | .... | .... | Reworked P. J. Seal indicated. |
| Ky-19...... | In River.......... | 0′ | 94′ | (?) | .... | .... | 91′ | Reworked P. J. Seal indicated. |
| Ky-19...... | Governor's Is..... | 10′ | 87′ | (?) | .... | .... | 77′ (?) | Reworked P. G. Seal indicated. |
| Ky-26...... | PH. L. nr. Atl.... | 0′ | 106′ | (?) | .... | .... | .... | Reworked P. J. Seal indicated. |
| Ky-27...... | E. Riv.–Atl....... | 6′ | 120′ | (?) | .... | .... | 82′ | Seal indicated. |
| Ky-28...... | Gold–Myrtle...... | 34′ | 134′ | (?) | .... | .... | 70′ | Reworked P. G. |
| K-78....... | Ft. Greene Pk..... | 52′ | 148′ | (?) | .... | .... | 73′ | Reworked P. G. and Cret. |
| K-78....... | Ft. Greene Pk..... | 59′ | 160′ | (?) | .... | .... | 74′ | Reworked P. G. and Cret. |
| K-78....... | Myrtle–N. Port... | 50′ | 320′ | (?) | .... | .... | 78′ | Reworked P. G. and Cret. |
| K-16....... | 385 Flatbsh....... | 35′ | 102′ | (?) | .... | .... | .... | Low salt. |
| Ky-32...... | PH. L. @ Coffey.. | 3′ | 114′ | (?) | .... | .... | 91′ | Reworked P. J. Seal indicated. |
| Ky-32...... | PH. L. @ Dike'm. | 3′ | 140′ | 106′ | (?) | .... | 117′ | Gard. in place Seal indicated. |
| Ky-32...... | BH. L. @ Dike'm. | 6′ | 100′ | (?) | .... | .... | .... | Reworked P. G. Seal indicated. |
| Ky-33...... | Wolcott–Fer...... | 8′ | 100′ | (?) | .... | .... | .... | Reworked P. G. Seal indicated. |
| Ky-33...... | Fer. nr. Dike'm... | 6′ | 159′ | 112′ | .... | .... | 133′ | All reworked Seal indicated. |
| Ky-33...... | Dike'm–Ferris..... | 10′ | 151′ | (?) | .... | .... | 121′ | Reworked P. J. Seal indicated. |
| K-159...... | 280 Richards...... | 7′ | 120′ | (?) | .... | .... | (?) | Reworked P. G. Very salt. |
| Ky-42...... | Col.–Halleck...... | 0′ | 91′ | (?) | .... | .... | .... | Reworked P. G. |
| Ky-43...... | Bryant–Henry.... | 0′ | 83′ | (?) | .... | .... | .... | Reworked P. J. and Crct. salt indicated. |
| Ky-34...... | Pion–Dwight...... | 7′ | 130′ | (?) | .... | .... | (?) | Reworked P. J. Seal indicated. |
| Ky-41...... | Mill nr. Hicks..... | 6′ | 127′ | 108′ | .... | .... | 121′ | Reworked P. J. |
| K-451...... | G'w's–Ham....... | 0′ | 161′ | (?) | .... | .... | .... | All reworked water salty. |
| Ky-35...... | Ham.–Hicks...... | 13′ | 135′ | 102′ | .... | .... | 107′ | Reworked P. J. |
| Ky-35...... | Hicks–Luquer..... | 13′ | 160′ | (?) | .... | .... | 117′ | 11′ decayed rock. |
| Ky-35...... | Hicks–Ham....... | 17′ | 113′ | (?) | .... | .... | (?) | Reworked P. J. and Cret. |
| Ky-35...... | Hicks–Ham....... | 15′ | 135′ | 100′ | .... | .... | 105′ | Reworked P. J. |
| K-158...... | 9 nr. Court....... | 20′ | 164′ | (?) | .... | .... | .... | All reworked and salty. |
| K-9........ | 9–Gowanus....... | 10′ | 155′ | 77′ (?) | .... | .... | .... | Reworked P. J. and Crct. salty. |
| K-9........ | 174 7 St.......... | 10′ (?) | 152′ | 85′ (?) | .... | .... | .... | Reworked P. J. and Cret. low salt (?) |
| Ky-43B.... | 8th–2nd Av....... | 9′ | 158′ | 134′ | 149′ (?) | .... | .... | Reworked P. J. Fresh water (?) |
| Ky-43A.... | 13 nr. 3rd........ | 28′ | 190′ | (?) | (?) | .... | .... | Reworked P. J. and Cretaceous Fresh water (?) |
| Ky-36...... | 2 Pl.–Clint....... | 46′ | 182′ | (?) | .... | .... | 116′ | Reworked P. J. |
| Ky-37...... | Pres.–Court....... | 46′ | 200′ | (?) | .... | .... | 134′ | Reworked P. J. |
| K-10....... | 3–Gowanus....... | 0′ | 164′ | (?) | .... | .... | .... | Reworked P. J. and Cret. seal indicated. |
| K-10....... | 3rd–Bond........ | 8′ (?) | 159′ | (?) | .... | .... | .... | Reworked P. J. and Cret. very salt. |
| K-345...... | 3rd–Hoyt......... | 28′ | 146′ | 97′ (?) | .... | .... | .... | Reworked P. J. Some salt. |
| Ky-38...... | Degraw–Smith.... | 28′ | 136′ | (?) | .... | .... | 88′ | Reworked P. G. Seal indicated. |
| Ky-38...... | Smith–Butler..... | 25′ | 159′ | (?) | .... | .... | 100′ | Reworked P. J. and Cret. seal indicated. |
| Ky-39...... | Wyckoff–Hoyt.... | 14′ | 107′ | (?) | .... | .... | 90′ | Reworked P. G. |
| Ky-39...... | Warren–Hoyt..... | 11′ | 115′ | (?) | .... | .... | 85′ | Reworked P. G. |
| Ky-40...... | Bergen–Bond..... | 21′ | 210′ | (?) | .... | .... | 169′ | Reworked P. J. and Cret. |
| Ky-40...... | Dean–Bond....... | 26′ | 163′ | (?) | .... | .... | 129′ | Reworked P. J. and Cret. |

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| K-118 | Scher.-Nevins | 43′ | 159′ | (?) | .... | .... | 91′ | Reworked P. G. |
| K-118 | Atl.-Nevins | 37′ | 214′ | (?) | .... | .... | 158′ | Reworked P. J. and Cret. |
| K-320 | 532 Fulton | 38′ | 114′ | (?) | .... | .... | 75′ | Reworked P. G. and Cret. |
| K-320 | Flat.-Fulton | 35′ | 125′ | (?) | .... | .... | 67′ | Reworked P. G. |
| K-277 | Nevins-Fult | 37′ | 146′ | (?) | .... | .... | 109′ | Reworked P. J. |
| K-17 | Laf-Rockwell | 38′ | 170′ | (?) | .... | .... | 107′ | Reworked P. J. |
| K-19 | 5th-Dean | 45′ | 227′ | (?) | 134′ (?) | .... | 160′ | Reworked P. J. |
| K-122 | 3 nr. Degraw | 18′ | 85′ | (?) | .... | .... | .... | Reworked P. G. |
| K-258 | Union-G'w's | 0′ | 122′ | (?) | .... | .... | .... | Reworked P. J. Salt. |
| K-156 | 3rd-3rd Ave | 15′ | 165′ | (?) | (?) | .... | .... | All reworked. |
| K-156 | 5th-4th | 10′ | 194′ | (?) | 144′ (?) | .... | .... | Reworked P. J. |
| K-156 | 5th-4th | 10′ | 188′ | (?) | 155′ (?) | .... | .... | Reworked P. J. |
| K-156 | 2nd-3rd | 14′ | 175′ | (?) | .... | .... | .... | All reworked seal indicated. |
| K-156 | 6th-4th | 35′ | 192′ | (?) | 145′ (?) | .... | .... | Reworked P. J. |
| K-156 | 6th-4th | 38′ | 197′ | 112′ | 147′ (?) | .... | .... | Reworked P. G. |
| K-156 | 6th-3rd | 15′ | 94′ | .... | .... | .... | .... | Reworked P. G. seal indicated. |
| K-156 | 6th nr. 4th | 40′ (?) | 202′ | (?) | (?) | .... | .... | Reworked P. J. & Cret. |
| K-252 | 8th nr. 4th | 45′ | 195′ | (?) | 132′ (?) | .... | .... | Reworked P. J. with seal. |
| K-252 | 326 9th | 63′ (?) | 131′ | .... | .... | .... | .... | Reworked P. G. |
| K-252 | 4th Ave | (?) | 200′ | .... | .... | .... | .... | Reworked P. J. with seal. |
| K-252 | 7th-4th | 42′ | 200′ | 94′ | 138′ (?) | .... | .... | Reworked P. J. with seal. |
| K-252 | 7th-4th | 42′ | 198′ | 101′ | 138′ (?) | .... | .... | Reworked P. J. with seal. |
| K-80 | 44 Ryerson | 20′ | 123′ | (?) | .... | .... | .... | Reworked P. G. |
| K-80 | 24 Hall | 29′ | 120′ | (?) | .... | .... | 91′ | Reworked P. G. |
| K-24 | 89 Steuben | 40′ | 120′ | (?) | .... | .... | .... | Reworked P. G. Fresh water. |
| K-33 | 404 Marcy | 14′ | 176′ | 82′ | 131′ | .... | .... | Jameco reworked Cret. |
| K-64 | Bart.-Flush | 15′ | 175′ | (?) | 109′ | .... | .... | Soft water in Jameco. |
| K-35 | Vern. nr. Sumn. | 75′ | 160′ | (?) | .... | .... | .... | Reworked P. G. |
| K-36 | Noll nr. Evgr | 49′ | 275′ | 88′ | (?) | .... | 226′ (?) | Reworked Cret. in touch Gard. |
| K-60 | 26 Rock | 28′ (?) | 310′ | 102′ (?) | .... | .... | 282′ | Reworked Cret. in touch Gard. |
| Ky-29 | Myt.-Clint | 59′ | 202′ | (?) | (?) | .... | 122′ | Reworked Cret. in touch Gard. |
| K-106 | 63 Carlton | 60′ (?) | 99′ | .... | .... | .... | .... | Reworked P. G. |
| Ky-30 | Laf.-Adel | 86′ | 40′ | .... | .... | .... | .... | All Wisconsin. |
| K-98 | Clift.-Grand | 64′ | 285′ | (?) | 107′ (?) | .... | 201′ | Reworked P. J. |
| K-20 | 700 Pacific | 52′ | 148′ | 94′ | .... | .... | .... | P. J. little disturbed. |
| K-22 | 470 Vandblt | 74′ | 139′ | .... | .... | .... | .... | All Wisconsin. |
| K-23 | 524 Waverley | 78′ | 228′ | (?) | .... | .... | 150′ (?) | Reworked P. J. |
| K-459 | Dean-Vandblt | 75′ | 140′ | .... | .... | .... | .... | Mostly Wisc. |
| K-129 | St. Mark-Grand | 114′ | 331′ | 103′ | .... | .... | 217′ (?) | Veatch No. 30. |
| K-31 | Bedfd.-Bergen | 89′ | 185′ | 87′ (?) | .... | .... | .... | Outwash P. G. under moraine. |
| K-130 | Bedfd.-Lin. Pl | 130′ (?) | 186′ | (?) | .... | .... | .... | Outwash P. G. under moraine. |
| K-131 | 1380 Fulton | 54′ | 312′ | 98′ | .... | .... | 258′ (?) | Outwash P. G. under moraine. |
| K-93 | Pul.-E. Throop | 55′ | 138′ | (?) | .... | .... | .... | Outwash P. G. at 88′. |
| K-38 | Lex.-E. Lewis | 55′ | 180′ | (?) | 127′ (?) | .... | .... | Soft water in Jameco. |
| K-90 | Bway.-Gates | 50′ | 109′ | .... | .... | .... | .... | Outwash P. G. |
| K-39 | Atl.-Roch | 61′ | 150′ | (?) | .... | .... | .... | Outwash P. G. under moraine. |
| K-299 | Irv.-Cooper | 65′ (?) | 130′ | .... | .... | .... | .... | Reworked P. G. |
| K-43 | E. N. Y. @ Barr. | 55′ | 165′ | 110′ (?) | .... | .... | .... | Outwash P. G. under moraine. |
| K-45 | 1632 Bushwick | 100′ (?) | 161′ | .... | .... | .... | .... | Outwash P. G. under moraine. |
| K-135 | Sned.-Lib | 55′ | 197′ | (?) | 142′ (?) | .... | .... | Reworked P. G. developed Jam. |
| K-136 | 315 Liberty | 50′ | 152′ | 102′ (?) | .... | .... | .... | Outwash P. G. under moraine. |
| K-539 | Logan-F. Tube | 43′ (?) | 284′ | (?) | (?) | .... | .... | G. app. elev. in Jam. at 241′. |
| K-539 | Logan-F. Tube | 43′ (?) | 284′ | 150′ (?) | 157′ (?) | .... | .... | Alternate log in Jam. at 241′. |
| K-539 | Logan-F. Tube | 62′ (?) | 284′ (?) | 130′ (?) | 138′ (?) | .... | .... | Alternate log in Jam. at 242′. |
| K-539 | Logan-F. Tube | 15′ (?) | 284′ (?) | 93′ (?) | 185′ (?) | .... | .... | Crosby No. 141. In Jam. at 269′. |

## SECTION III—KINGS COUNTY

An outstanding feature of this Section is the absence of economically important water-bearing structure other than Post-Gardiners. Salt water surrounds it on all sides, except along its arbitrary southern boundary line from the southeast Navy Yard corner to the tip of English Kills. North of Metropolitan Avenue in Greenpoint, Cretaceous sediments either in place or reworked, are directly in contact with a thin Wisconsin mantle, and so intermingled by reworking that there is no definite line of demarkation between them. Rising Cretaceous sediments preclude water development here except along Newtown Creek and East River, where salt water infiltration affords irregular supply.

South of Metropolitan Avenue, sediments of Cretaceous origin drop sufficiently below tide for overlying Post-Gardiners to provide underground water storage. This originates almost entirely in the form of diffusion of Post-Gardiners water from under Section II as indicated by the projection of the northern Crater "knob" into Section III.

Bed rock ranges from El.—50 to El.—100 above Nassau Avenue, but pitches southward of this to depths ranging around El. —200 near English Kills. Bed rock troughs which apparently formerly contained tributaries of the Sound River Valley, exist under both the western and eastern sides of Williamsburg. The eastern trough follows the general line of Newtown Creek, but its gradient changes from eastward to westward at a saddle in the vicinity of Greenpoint Avenue.

Usually, the bottom of Post-Gardiners sediments is too vague for recording because they have been reworked and intermingled with Cretaceous and even possibly Jameco in a few cases. Such Jameco sediments as may exist wherever rock stands below El. —125 more or less, have little if any, water-bearing value.

### Section III—Kings County

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| K-571...... | Noble-West...... | 10′ | 610′ | .... | .... | .... | 80′ | Reworked Cret. and P. G. |
| Ky-O...... | West-Greene..... | 7′ | 53′ | .... | .... | .... | 46′ | Reworked P. G. |
| Ky-O...... | Mnh.-Greene..... | 13′ | 54′ | .... | .... | .... | 31′ | Reworked Cret. and P. G. |
| K-465...... | Pdge.-Shawn..... | 6′ | 52′ | .... | .... | .... | .... | Reworked Cret. and P. G. |
| K-465...... | Mnh.-New Cr.... | 0′ | 60′ | .... | .... | .... | 49′ | Reworked Cret. and P. G. |
| K-465...... | Dupnt-Oakland... | 10′ | (?) | .... | .... | .... | 75′ | Reworked Cret. and P. G. |
| Ky-1....... | Whale Creek...... | 0′ | 63′ | .... | .... | .... | 63′ | Reworked Cret. and P. G |
| Ky-1....... | Kng'd-N. Hen.... | 3′ | 85′ | (?) | .... | .... | 82′ | Reworked P. G. |
| K-579...... | Grnpt.-Kng'd..... | 7′ | 825′ | .... | .... | .... | 75′ | Reworked P. G. |
| K-579...... | Grnpt.-New Cr... | 0′ | 74′ | .... | .... | .... | .... | Reworked P. G |
| Ky-2....... | Meek.-Brgwtr.... | 17′ | 171′ | (?) | .... | .... | 117′ | Reworked Cret. and P. J. |
| Ky-2....... | Meek.-Varick..... | 31′ | 160′ | .... | .... | .... | 111′ | Reworked Cret. and P. J. |
| Ky-2....... | Meek.-Vandam... | 45′ | 176′ | .... | .... | .... | 110′ | Reworked P. J. |
| Ky-7....... | PHL-N. 7th...... | 0′ | 111′ | 95′ (?) | .... | .... | 107′ | Reworked Cret. and P. J. |
| Ky-7....... | 1400′ in Riv...... | 0′ | 92′ | (?) | .... | .... | 84′ | Reworked Cret. and P. J. |
| K-50....... | N. 10-Berry...... | 28′ | 157′ | (?) | .... | .... | 129′ | Reworked Cret. and P. J. |
| K-49....... | N. 11-Berry...... | 18′ | 333′ | 82′ (?) | .... | .... | 114′ | Reworked Cret. and P. J. |
| Ky-9....... | BHL-S. 5th...... | 0′ | 114′ | (?) | 98′ | .... | 98′ | Reworked Cret. and P. J. |
| K-458...... | S. 4th-Kent...... | 5′ | 1053′ | (?) | .... | .... | 173′ | Reworked Cret. and P. J. |

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| Ky-10 | Bway-BHL | 0′ | 146′ | (?) | (?) | .... | 146′ (?) | Reworked Cret. and P. J. seal indicated. |
| Ky-10 | Bway-Kent | 15′ | 132′ | (?) | .... | 115′ (?) | 117′ | Reworked Cret. and P. J. |
| Ky-12 | Wash.-Wall. Ca. | 3′ | 101′ | .... | .... | .... | .... | Reworked P. G. seal indicated. |
| K-568 | Navy Yard | 8′ | 108′ | .... | .... | .... | 93′ | All reworked; seal indicated. |
| K-568 | Navy Yard | 8′ | 129′ | .... | .... | .... | 95′ | All reworked; seal indicated. |
| K-568 | Navy Yard | 8′ | 220′ | .... | .... | .... | 88′ | All reworked: seal indicated. |
| K-68 | Flush.-Clint | 14′ | 195′ | 101′ | 121′ | .... | 161′ | Little disturbed. |
| K-68 | Metz-Flmn. | 7′ | 179′ | .... | .... | .... | 152′ | Reworked P. G. seal indicated. |
| Ky-13 | C-East Av | 13′ | 190′ | 108′ | (?) | .... | 159′ | Reworked Cret. under Wisc. |
| K-565 | 556 Kent | 5′ | 130′ | 97′ | .... | .... | .... | Reworked Cret. and P. G. |
| K-565 | Keap-Wythe | 17′ | 179′ | 105′ | .... | .... | 142′ | Reworked Cret. and P. G. |
| Ky-11 | Bdfd-Rodney | 43′ | 200′ | (?) | .... | .... | 132′ | Outwash P. G. (?). |
| K-67 | Keap-Lee | 55′ | 214′ | (?) | .... | .... | 149′ | Reworked P. J. |
| K-331 | Keap-Div | 45′ | 202′ | 99′ | (?) | .... | 143′ | Reworked P. J. |
| K-331 | Keap-S. 5th | 32′ | 152′ | 95′ (?) | .... | .... | 100′ | Reworked Cret. and P. J. |
| K-331 | Keap-S. 4th | 25′ | 163′ | (?) | .... | .... | 121′ | Reworked Cret. and P. J. |
| K-331 | Bway-Div | 45′ (?) | 202′ | 97′ | (?) | .... | 141′ | Reworked Cret. and P. J. |
| K-331 | Bway-Keap | 32′ | 174′ | (?) | .... | .... | 119′ | Reworked Cret.:and P. J. |
| K-331 | Keap-S. 5th | 29′ | 144′ | .... | .... | .... | 77′ | All reworked. |
| K-331 | Keap-S. 5th | 19′ | 142′ | .... | .... | .... | 103′ | All reworked. |
| Ky-8 | Keap-Grand | 20′ | 171′ | (?) | (?) | .... | 131′ | Reworked Cret. and P. J. |
| K-56 | Met. @Union | 14′ | 196′ | .... | .... | .... | 162′ | Reworked Cret. and P. J. |
| Ky—4 | Lor.-Jackson | 18′ | 187′ | .... | .... | .... | 149′ | Reworked Cret. and P. J. |
| Ky-3 | Meeker-Mnh | 10′ | 194′ | .... | .... | .... | 164′ | Reworked Cret. and P. J. |
| K-461 | Meeker-Kngd | 35′ | 218′ | (?) | .... | .... | 163′ | Reworked Cret. and P. J. |
| K-461 | Meek.-Mon | 34′ | 189′ | (?) | .... | .... | 135′ | Reworked Cret. and P. J. |
| Qx-44 | Masp.-New Cr. | 8′ | 217′ | (?) | .... | .... | 209′ (?) | Reworked Cret. in touch Gard. |
| Ky-6 | Grand-New. Cr. | 0′ | 69′ | .... | .... | .... | .... | All reworked. |
| K-567 | Masp.-Gard | 5′ | 185′ | 92′ (?) | .... | 155′ | 175′ | Reworked Cret. and P. J. |
| K-567 | Masp.-Gard | 11′ | 223′ | (?) | .... | .... | 192′ | Reworked Cret. and P. J. |
| K-569 | Masp.-Morg | 19′ | 215′ | .... | .... | 97′ (?) | 177′ | Reworked Cret. and P. J. |
| K-569 | Masp.-Porter | 5′ | 190′ | .... | .... | .... | .... | Reworked Cret. in touch Gard. |
| Ky-5 | Masp.-Metro | 39′ | 221′ | (?) | .... | .... | 162′ | Reworked Cret. and P. J. |
| K-57 | Mauj.-Humb | 48′ | 137′ | (?) | .... | .... | .... | Reworked P. J. |
| K-57 | 257 Ten Eyck | 43′ (?) | 195′ | 57′ (?) | .... | .... | 152′ | Reworked Cret. in touch Gard. |
| K-57 | 257 Ten Eyck | 20′ (?) | 240′ | .... | .... | .... | 220′ (?) | Crosby No. 62. Reworked Cret. in touch Gard. |
| K-57 | Mauj.-Bush | 50′ | 112′ | .... | .... | .... | .... | Reworked P. J. |
| K-426 | Ten Ey.-Grah | 35′ | 104′ | (?) | .... | .... | .... | Reworked P. G. |
| K-426 | Stagg-Mnh | 36′ | 120′ | .... | .... | .... | .... | Reworked P. G. |
| K-426 | 180 Schoels | 38′ | 140′ | .... | .... | .... | .... | Reworked Cret. in touch G. (?). |

## SECTION I—QUEENS COUNTY

About half of Queens lying south of Interborough and Grand Central Parkways has one outstanding geologic feature, this being the only province within the City where full normal development of Cretaceous and Pleistocene sediments, somewhat similar to Nassau, may be found. The Parkways forming its northern boundary run along the crest of the Brooklyn Moraine. Paralleling this boundary line is a disturbed zone with overthrust deposition, resulting from ice shove over the Sound River's left valley wall scarp. Under Jamaica and Hollis is a noteworthy elevation of Gardiners, and possibly its underlying formations. Cretaceous and Jameco appear somewhat intermingled and well data are conflicting. Apparently, sediments with Cretaceous characteristics are, in places, above formations that can only be Jameco. In tabulating Section I well

data, these higher Cretaceous features are ignored as over-deposits, and the Cretaceous land surface assumed to range between El. —170 and El. —200 in the Jamaica-Hollis sector.

Bed rock pitches from about El. —450 at the southwest corner of Forest Park to approximately El. —1300 under the Atlantic shore at Far Rockaway. The top of the Lloyds ranges between El. —400 around Woodhaven to El. —930 at Far Rockaway. Evidence of Lloyds arching (possibly even folding) from ice shove along the northern boundary is particularly indicated at Creedmoor. The Hospital wells lie due south of Alley Pond so the Lloyds disturbance noted in them may be from folding or arching ahead of the Ice projection which formed Little Neck Bay.

Water interchange between Magothy and Lloyds may occur in the zone where Cretaceous sediments were disturbed parallel to the line of the original Valley wall scarp. Magothy Sand does not appear to be an aquifer anywhere north of Jamaica Avenue, yet its attenuations extend through this zone into the Valley proper. In the eastern part of Section I the Magothy becomes more persistent and takes on the character of an aquifer. Moreover, it persistently shows up as a water-bearing formation south of Jamaica Bay. Therefore, the Magothy may have unrealized economic value in much of the territory south of Jamaica Avenue.

Jameco north of Sunrise Highway varies greatly both in thickness and character. In places it lacks good water-bearing qualities. Sometimes, it becomes quite thin, apparently where it overlies higher peaks of the old land surface. Generally in this northern part of Section I Jameco lacks the degree of classification which it has in the Sound River Valley. This may possibly be due to the vacillating character of the Ice outwash action by which it was deposited. South of Sunrise Highway thick and persistent Jameco deposits rest upon the terraciform Cretaceous land surface previously mentioned. Apparently, however, Jameco is not very prolific in water yield under the Rockaways, because wells drilled below the Gardiners all seem to go down to either Magothy or Lloyds. Moreover, such data as are available from wells in the Rockaways record large amounts of lignite and other vegetal matter in the Jameco zone. This would indicate that Jameco along the South Shore was deposited in lagoons behind barrier beaches. North of the Bay Jameco presumably contains fresh water, but there are no reliable data on the saline content beneath the Rockaways. Gardiners ranges around El. —100 along lat. 40° 40′, occasionally standing as high as El.—60. Southward, it pitches beneath Jamaica Bay reaching approximately El.—200 under the Rockaways. Post-Gardiners is generally salty south of the Bay, possibly continuing so northward under it, since no seal appears along the Rockaway shores.

Lloyds and Post-Gardiners are the important water-bearing horizons in Section I, but the Jamaica Water Company has good wells drawing from Jameco and in a few places, Magothy Sand.

Recently taken water levels indicate free interchange between Jameco and Post-Gardiners. The water table in these Post-Cretaceous aquifers ranges from approximately El. +35 in the moraine hills north of Hollis, down to sea level near the Jamaica Bay shore line, sloping generally south and westward. Apparent inconsistencies shown by water elevation measurements in the following tabulation arise from the necessity of recording during temporary shutdowns of units, while pumping continues elsewhere.

In sharp contrast to Post-Cretaceous water levels, those in Lloyds and Magothy stand below tide. This noteworthy segregation between Cretaceous and Post Cretaceous water levels prevails over the Jamaica franchise area north of Sunrise Highway. Yet, south of the Highway, the static table of the Lloyds stands above tide! Evidently, then, deep pumping in Jamaica creates a widespread cone of depression of Cretaceous water levels in order to draft upon remote storage, probably to the eastward. At the same time this cone of depression does not appear to directly affect water levels in Jameco and Post-Gardiners. Long range interference between deep Jamaica wells and those of the City's North Shore stations which penetrated Lloyds, has been demonstrated within the past year. This leaves little question about the far reaching nature of water interchange along the Lloyds horizon.

## Section I—Queens County

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | U. P. | Mag. | L. P. | Lds. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q-237 | 91-Atlantic | 37′ | 577′ | ..... | ..... | 176′ (?) | ..... | ..... | ..... | 399′ | 519′ | |
| Q-322 | 127-Metro | 77′ | 130′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. st. under mor. 0′. |
| Q-301 | 127-Metro | 64′ | 110′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +2′. |
| Q-317 | 123-89th | 58′ | 565′ | 87′ | 140′ | 234′ | ..... | ..... | ..... | 427′ | ..... | Lds. st. 16′. |
| Q-317 | 123-89th | 58′ | 291′ | 107′ | 140′ | 233′ (?) | ..... | ..... | ..... | ..... | ..... | Jam. st. +1′. |
| Q-308 | 131-88th | 62′ | 107′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. st. under mor. +6′ |
| Q-308 | 131-88th | 63′ | 560′ | (?) | 190′ | 251′ (?) | ..... | ..... | 353′ (?) | 417′ | ..... | Lds. st. 12′. |
| Q-246 | 124-Atlant | 35′ (?) | 550′ | ..... | ..... | ..... | ..... | ..... | ..... | 515′ (?) | ..... | Developed Lds. |
| Q-318 | 164-84th | 128′ | 250′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. st. under mor. +8′ |
| Q-318 | 164-84th | 128′ | 635′ | 72′ | (?) | (?) | ..... | ..... | 327′ | 413′ | ..... | Lds. st. +7′ old J. & Cret. mxd. |
| Q-302 | 162-89th | 56′ | 104′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. st. under mor. +13′. |
| Q-302 | 162-89th | 56′ | 197′ | 58′ (?) | 93′ (?) | ..... | ..... | ..... | ..... | ..... | ..... | Jam. st. +17′ (?). |
| Q-319 | Cedft-Homln | 121′ | 142′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. st. under mor. +16′. |
| Q-320 | Evgr.-Dent | 104′ | 476′ | (?) | (?) | ..... | (?) | 285′ | ..... | ..... | ..... | Mixed Jam. & Cret. |
| Q-306 | Sta. No. 1 | 23′ (?) | 352′ | 97′ (?) | 117′ (?) | 212′ | 212′ | (?) | ..... | ..... | ..... | Veatch No. 213 |
| Q-306 | Sta. No. 1 | 25′ | 783′ | ..... | ..... | ..... | ..... | ..... | ..... | 555′ | 650′ | Test well. |
| Q-306 | 167-108 Dr | 23′ | 97′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +5′. |
| Q-306 | 167-109 Dr | 23′ | 78′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +6′. |
| Q-306 | 167-Brink | 21′ | 97′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +3′. |
| Q-306 | 164-109 Dr | 24′ (?) | 681′ | 66′ (?) | ..... | (?) | 237′ | ..... | 410′ | 457′ | 648′ | Lds. st. 16′. |
| Q-324 | 179-107 | 30′ | 423′ | 76′ (?) | 108′ (?) | (?) | ..... | ..... | ..... | ..... | ..... | Cre. st. +8′ (?). |
| Q-324 | Stm. No. 2 | 28′ | 637′ | (?) | (?) | (?) | ..... | 308′ (?) | ..... | 569′ | 609′ | Test well. |
| Q-324 | 179-107th | 29′ (?) | 123′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +8′ (?). |
| Q-324 | 108-Wats | 29′ (?) | 62′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +10′. |
| Q-324 | 180-106 Rd | 28′ (?) | 62′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +6′. |
| Q-305 | 199-93rd | 59′ | 407′ | 86′ (?) | 91′ (?) | (?) | 234′ | 310′ | ..... | ..... | ..... | Veatch No. 220 J. & G. app. mixed. |
| Q-305 | 199-93rd | 60′ | 92′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +29′. |
| Q-307 | 209-93rd | 68′ | 138′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. under moraine +26′. |
| Q-307 | 209-93rd | 68′ | 299′ | (?) | 143′ (?) | 221′ (?) | ..... | ..... | ..... | ..... | ..... | Jam. st. +29′. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q-307 | 209–93rd | 67′ | 96′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. under moraine +26′. |
| Q-313 | 214th–89th | 94′ | 111′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. under moraine +37′. |
| Q-321 | Saw–Rock H. | 139′ | 152′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. under moraine +32′. |
| Q-72 | Crdmr. Hosp | 100′ | 660′ | 96′ (?) | (?) | (?) | 300′ (?) | 308′ | 492′ | 540′ | ..... | Flded. G. & J. under Wis. |
| Q-72 | Crdmr. Hosp | 100′ | 690′ | (?) | 90′ (?) | (?) | ..... | ..... | 475′ (?) | 500′ | ..... | Reworked J. & G. mixed with Wis. |
| Q-72 | Crdmr. Hosp | 100′ | 701′ | (?) | (?) | 143′ (?) | 143′ (?) | (?) | 471′ | 549′ | ..... | All reworked Cret. elev. mixed with Jameco. |
| Q-303 | 120th–111th | 31′ | 100′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | F. G. st. 2′...................... |
| Q-303 | 120th–111th | 32′ | 163′ | 128′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. 5′. |
| Q-304 | 128th–Sutter | 14′ | 71′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +7′. |
| Q-304 | 128th–Sutter | 14′ | 214′ | 99′ | 145′ | ..... | ..... | ..... | ..... | ..... | ..... | Jam. st. 1′. |
| Q-311A | 139–109 Rd. | 25′ | 122′ | 86′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 211. |
| Q-311 | 143–111th | 25′ | 260′ | (?) | 180′ (?) | 205′ (?) | ..... | ..... | ..... | ..... | ..... | Jam. st. +2′. |
| Q-306A | 153–109 Dr. | 19′ | 200′ | 76′ (?) | 170′ | (?) | ..... | ..... | ..... | ..... | ..... | Veatch No. 212, Brook No. 11. |
| Q-314 | 144th–166th | 32′ | 310′ | 86′ | 163′ | 218′ (?) | ..... | 218′ (?) | ..... | ..... | ..... | Jam. st. 5′. |
| Q-312 | 178th–130th | 19′ | 276′ | ..... | (?) | 194′ (?) | ..... | 194′ (?) | ..... | ..... | ..... | Jam. st. +9′. |
| Qx-74 | 221–132 Av. | 27′ | 357′ | (?) | (?) | 200′ (?) | ..... | 298′ (?) | ..... | ..... | ..... | Veatch No. 295. |
| Q-310 | 224–Foch | 45′ | 111′ | (?) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. st. +25′. |
| Q-323 | 224–115th | 46′ | 869′ | 111′ (?) | 160′ (?) | 316′ (?) | 359′ | (?) | 548′ | 558′ | 815′ | Edge Nass. Val. (?). |
| Q-323 | 224–115th | 46′ | 377′ | 111′ (?) | 160′ (?) | 316′ (?) | ..... | 231′ (?) | ..... | ..... | ..... | Jam. st. +15′. |
| Q-340 | Spring Cr. | 9′ | 148′ | 115′ | 130′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 137 Test No. 4. |
| Q-340 | Spring Cr. | 9′ | 162′ | 118′ | 124′ | ..... | ..... | ..... | ..... | ..... | ..... | |
| Q-345 | Woodhvn St. | 10′ | 219′ | 90′ | 116′ | 191′ (?) | ..... | ..... | ..... | ..... | ..... | Test well. |
| Q-345 | Woodhvn St. | 11′ | 191′ | 84′ (?) | 95′ (?) | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 136. |
| Q-352 | Church–LIRR | 25′ (?) | 658′ | 100′ | (?) | 215′ (?) | ..... | (?) | 494′ (?) | 495′ (?) | 625′ | Test well, Lds. st. +8′. |
| Q-344 | Aqudct St. | 10′ | 336′ | (?) | 148′ | 226′ | ..... | 245′ (?) | ..... | ..... | ..... | Test well. |
| Q-344 | Aqudct St. | 10′ | 306′ | 120′ | 148′ | 222′ | ..... | 234′ (?) | ..... | ..... | ..... | Test well. |
| Q-343 | Shetckt St. | 13′ | 154′ | 124′ | 133′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 195. |
| Q-339 | Oconee St. | 10′ | 207′ | (?) | 176′ | ..... | ..... | ..... | ..... | ..... | ..... | |
| Q-339 | Oconee St. | 10′ | 212′ | 100′ | 172′ | ..... | ..... | ..... | ..... | ..... | ..... | Well No. 34. |
| Q-339 | Oconee St. | 10′ | 192′ | 105′ | 175′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 199. |
| Q-338 | Morris P. St. | 10′ | 235′ | 91′ | 171′ | 235′ (?) | ..... | ..... | ..... | ..... | ..... | Test well. |
| Q-338 | Morris P. St. | 10′ | 51′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 210. **Outwash P. G. at bottom.** |
| Q-337 | Baiseleys | 8′ | 222′ | 106′ | 152′ | ..... | ..... | ..... | ..... | ..... | ..... | |

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | U. P. | Mag. | L. P. | Lds. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q-337 | Baiseleys | 7′ | 200′ | 99′ | 149′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 200. |
| Q-336 | Jameco St. | 10′ | 173′ | 80′ | 133′ | ..... | ..... | ..... | ..... | ..... | ..... | Well No. 4. |
| Q-336 | Jameco St. | 2′ | 150′ | 77′ | 135′ | ..... | ..... | ..... | ..... | ..... | ..... | Well No. 4A. |
| Q-336 | Jameco St. | 7′ | 161′ | 130′ | 77′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 201. |
| Qx-72 | 153-Con. Bd. | 6′ | 156′ | 83′ | 136′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 202 |
| Qx-73 | Byron-Con | 7′ | 257′ | 77′ | 146′ | 250′ (?) | ..... | ..... | ..... | ..... | ..... | Veatch No. 203. |
| Q-335 | St. Alb. St. | 12′ | 335′ | 70′ | 148′ | 285′ (?) | ..... | ..... | ..... | ..... | ..... | Test well. |
| Q-335 | N. Y. Av. Con | 10′ | 277′ | 77′ | 148′ | 151′ (?) | ..... | ..... | ..... | ..... | ..... | Test No. 3. |
| Q-335 | N. Y. Av.-Con | 10′ | 277′ | 76′ | 191′ | 267′ (?) | ..... | ..... | ..... | ..... | ..... | Veatch No. 204. |
| Qx-75 | Farm. Av-Con | 10′ | 295′ | (?) | 201′ | 248′ (?) | ..... | ..... | ..... | ..... | ..... | Test No. 8. |
| Qx-75 | Farm. Av-Con | 10′ | 293′ | (?) | 202′ | 250′ (?) | ..... | ..... | ..... | ..... | ..... | Veatch No. 205. |
| Qx-76 | Springfld St. | 16′ | 419′ | 68′ (?) | 166′ | (?) | ..... | ..... | ..... | ..... | ..... | Test No. 7. |
| Qx-76 | Springfld St. | 10′ | 420′ | 68′ | 160′ | (?) | ..... | ..... | ..... | ..... | ..... | Veatch No. 206. |
| Q-334 | Springfld St. | 8′ | 190′ | 67′ | 103′ | ..... | ..... | ..... | ..... | ..... | ..... | |
| Q-334 | Springfld St. | 14′ | 190′ | (?) | 116′ (?) | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 289. |
| Q-334 | Springfld St. | 7′ | 178′ | 71′ | 116′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 196. |
| Q-333 | Rosedale St. | 12′ | 140′ | (?) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| Qx-78 | 232-Cond. Bd. | 18′ | 406′ | 80′ | 170′ | 205′ (?) | ..... | 312′ (?) | ..... | ..... | ..... | Test No. 12. |
| Q-332 | For. Str. St. | 8′ | 375′ | 111′ | 132′ | 259′ (?) | ..... | 337′ (?) | ..... | ..... | ..... | Veatch No. 290. |
| Qx-79 | 245-Cond. Bd. | 22′ | 412′ | 80′ | 108′ | (?) | ..... | (?) | ..... | ..... | ..... | Veatch No. 292. |
| Qx-80 | 248-Cond. Bd. | 17′ | 390′ | (?) | 118′ (?) | ..... | ..... | 348′ | ..... | ..... | ..... | Test No. 14. |
| Qx-80A | 159-Cor. Bas | 5′ (?) | 203′ | 135′ | 197′ | ..... | ..... | ..... | ..... | ..... | ..... | Veatch No. 193. |
| Q-290 | Rock'y Pt. | 5′ | 728′ | 195′ | 201′ | 425′ | 425′ | 518′ (?) | 605′ | 674′ | ..... | |
| Q-290 | Rock'y Pt. | 5′ | 720′ | 190′ | 202′ | 464′ (?) | ..... | ..... | 567′ | 568′ | ..... | Crosby No. 129A. |
| Q-291 | 110-Rock Bd | 6′ | 1,260′ | 191′ | 237′ | 463′ (?) | 674′ | 724′ | ..... | 862′ | 1,244′ | Lds. st. +8′. |
| Q-123 | 108-LIRR. | 4′ | 948′ | 200′ | 247′ | 459′ | 685′ | 755′ | 829′ | 861′ | ..... | Lds. st. +7′. |
| Q-288 | 96-Chan. Dr. | 5′ | 870′ | 192′ | 206′ | 486′ | 643′ (?) | (?) | ..... | 865′ (?) | ..... | |
| Q-111 | B. 24-Enr. Rd | 9′ | 1,116′ | (?) | ..... | 415′ | 729′ | 853′ | (?) | 931′ | ..... | Lds. st. +9′. |

## SECTION II—QUEENS COUNTY

North of the Parkways is a province designated as Section II covering the balance of Queens, except a northwest sector between Flushing Bay and Newtown Creek. This section includes most of the Sound River Valley in Queens, but its distinctive geologic feature is the possible existence of Lloyds everywhere under it. Along its arbitrary northwest boundary line Lloyds seems to "feather" out over bed rock. The left Valley wall scarp runs along the south of the belt between Horace Harding Boulevard and Grand Central Parkway east of Flushing Meadows. The Queens Moraine diagonals across this belt from Cedar Grove Cemetery to Alley Pond. Breaks in the Queens Moraine at Flushing and Bayside Meadows were created when ice melted from beneath the original Moraine material. West of Flushing Meadows the Queens Moraine bears across the southern part of Elmhurst towards the Calvary Cemetery area north of Maspeth Creek.

Everywhere north of the older Moraine Gardiners and Jameco are too badly reworked and disrupted for their elevations to be accurately recorded. Moreover, Jameco loses much of its water-bearing value, particularly west of Flushing Meadows. Such water as is found in it east of the Meadows in Flushing, Bayside and Douglaston occurs in reworked Jameco that may be somewhat intermingled with Post-Gardiners. Generally, it seems safe to assume that the Post-Cretaceous water resources north of the Queens Moraine have no distinct separation between Jameco and Post-Gardiners.

South of the Moraine Jameco is presumably an excellent aquifer, though little drilling has been done into it. The Glendale well of the Long Island R. R. revealed prolific water of high iron content in the Jameco. Also, certain City wells south of Little Neck Bay appear to draw upon the Jameco, though formations here are so disturbed one cannot be sure.

Post-Gardiners between the Moraines east of Flushing Meadows is very thick. It consists of great masses, heaped above and south of the Queens Moraine, that form the highest land of the two Counties, and lie partly over the Valley and partly south of it. The greatest elevation in ground water tables occurs towards the western end of the Brooklyn Moraine with a slight northern and western dip over the Valley proper. However, there appears to be an elevated mound in the water table slightly north of the Queens Moraine. This would suggest a probability that the Moraine forms some sort of an impermeable "dike" which isolates the water in the area north of it.

Bed rock elevations range between El. —100 at College Point and El. —550 where Grand Central Parkway crosses the County line. Along the indicated line of Lloyds vanishment west of Flushing Bay bed rock ranges between El. —225 and El. —250. Lloyds varies with bed rock, being only —104 feet in Whitestone and exceeding —400 feet at Alley Pond. Evidence of

Magothy Sand is found on both sides of the eastern end of the Sound River Valley, with outcroppings along the Cretaceous scarp towards the west.

Arching, folding and intermingling of Jameco and Cretaceous are persistently indicated by all deep wells of the Sound River Valley area. Great disturbance is particularly noticeable south of Little Neck Bay where Jameco is too badly reworked to be distinguished in many wells.

## Section II—Queens County

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | U. P. | Mag. | L. P. | Lds. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Qx-1 | 128–Talm. Dr. | 6′ | 149′ | ..... | ..... | 86′ | ..... | ..... | 86′ (?) | 104′ | 143′ | Reworked Cret. |
| Qx-2 | 151–Cove Bd | 0′ | 185′ | ..... | ..... | 16′ (?) | ..... | ..... | ..... | ..... | ..... | Cret. elevated. |
| Qx-3 | 154th–7th | 18′ (?) | 120′ | (?) | ..... | 67′ (?) | ..... | ..... | ..... | ..... | ..... | Cret. elevated. |
| Qx-4 | 162–12th | 20′ | 79′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Reworked P. G. |
| Q-98 | C. I. Bd.–Lock | 72′ (?) | 87′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under boulders. |
| Q-33 | 121–15th | 37′ | 220′ | ..... | ..... | (?) | ..... | ..... | 97′ (?) | 126′ | 193′ | Reworked P. C. |
| Q-279 | Whstn. Sta | 5′ | 216′ | ..... | ..... | (?) | ..... | ..... | 145′ | 154′ | 207′ | Reworked Cret. and P. J. |
| Q-279 | Whstn. Sta | 10′ | 218′ | ..... | ..... | 130′ | ..... | ..... | 140′ | 148′ | 203′ | Reworked F. C. |
| Q-279 | Whstn. Sta | 11′ | 219′ | ..... | ..... | (?) | ..... | ..... | 139′ | 192′ | 204′ | Reworked P. C. |
| Q-279 | Whstn. Sta | 11′ | 226′ | ..... | ..... | ..... | ..... | ..... | ..... | 166′ | ..... | Reworked above Lds. |
| Q-279 | Whstn. Sta | 12′ | 224′ | ..... | ..... | 100′ | ..... | ..... | 106′ | 140′ | 212′ | Reworked P. C. |
| Q-279 | Whstn. Sta | 10′ | 200′ | ..... | ..... | (?) | ..... | ..... | 111′ (?) | 155′ | ..... | Reworked P. C. |
| Q-183 | 22–26 119th | 9′ | 170′ | ..... | ..... | 111′ (?) | ..... | ..... | 111′ | 141′ | ..... | All reworked Cret. |
| Qx-84 | 120–No. Bd. | 16′ | 50′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All Wisconsin. |
| Qx-85 | No. Bd.–Flush | 11′ | 85′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-85 | Flush. Mead | 0′ | 71′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Q-178 | 32 @Miller | 12′ | 264′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 252′ (?) | |
| Q-34 | 34–Collins | 34′ | 250′ | ..... | ..... | ..... | ..... | ..... | ..... | (?) | 216′ | Water in Lds. |
| Q-26 | 35–Farrngtn | 30′ (?) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | (?) | 261′ (?) | No water in Lds. |
| Qx-86 | 120–Roosevlt | 11′ | 83′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |
| Qx-87 | 127–Roosevlt | 22′ | 164′ | (?) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-87 | 127–Roosevlt | 20′ | 172′ | (?) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-87 | 127–Roosevlt | 16′ | 175′ | 104′ (?) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-88 | Roose.–Flush | 0′ | 156′ | 89′ (?) | ..... | 106′ | ..... | ..... | 149′ | ..... | ..... | Wis. under marsh, Cret. elevated in touch Gard. |
| Qx-88 | Roose.–Flush | 0′ | 100′ | (?) | ..... | ..... | ..... | ..... | 88′ (?) | ..... | ..... | Cret. elevated. |
| Q-127 | Main–38 Ave | 40′ | 214′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Reworked Cret. & P. J. in touch G. |
| Q-65 | LIRR–G. C. Pky. | 10′ (?) | 284′ | 79′ | 200′ (?) | 233′ | ..... | 200′ (?) | 233′ (?) | 239′ | 274′ (?) | Water in Lds. Reworked P. C. |
| Q-65 | 46–114th | 11′ | 81′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Q-65 | 46–120th | 11′ | 99′ | 88′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | U. P. | Mag. | L. P. | Lds. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q-65 | 46-114th | 27′ | 94′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |
| Qx-90 | 123rd-46th | 4′ | 91′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |
| Qx-91 | LIRR-Flu. R | 1′ | 76′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |
| Qx-46 | 117th-50th | 36′ | 143′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-46 | 120th-52nd | 27′ | 121′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-46 | 120th-Roose | 30′ | 128′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-47 | Fowler Av. | 2′ | 85′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-49 | Anthony-Lau | 10′ | 94′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-53 | 54-G. C. Pky | 35′ | 113′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-53 | 58-G. C. Pky | 27′ | 103′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-54 | 123-Flu. Cr. | 2′ | 107′ | 80′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-56 | 58-G. C. Pky | 10′ | 86′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-56 | 111th-57th | 17′ | 83′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-56 | 58-Corona | 13′ | 60′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Reworked P. G. |
| Qx-57 | Gil. H. H. Bd. | 7′ | 78′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-58 | Nass. Fl. Riv | 1′ | 90′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Reworked P. G. under marsh. |
| Qx-58 | 130-62 Rd. | 2′ | 82′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-58 | 62 Rd.-Fl. R. | 2′ | 82′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh (?). |
| Qx-58 | Nass. Fl. Riv | 2′ | 70′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |
| Qx-58 | 130-Nass. Bd | 9′ | 73′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |
| Qx-59 | Fl. R. nr. 63 | 2′ | 83′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | P. G. under marsh. |
| Q-274 | Cal. Test Fl. | 5′ | 407′ | 64′ (?) | (?) | 87′ | 262′ | 284′ | ..... | 373′ | 402′ | Elv. Cret. in touch rewkd. Jam. & Gard. |
| Q-281 | Flush. Sta. | 5′ | 432′ | (?) | (?) | 130′ | 130′ (?) | ..... | (?) | 375′ | 427′ (?) | Elev. Cret. in touch P. J. |
| Q-281 | Flush. Sta. | 21′ | 123′ | (?) | (?) | 89′ (?) | 89′ (?) | ..... | ..... | ..... | ..... | Elv. Cret. rewkd. J. & G. |
| Q-282 | Flush. Sta. | 30′ | 463′ | 94′ | 105′ | 133′ | 133′ (?) | 277′ | 330′ (?) | 335′ | 433′ (?) | Flded Cret. (?) mxd. Jam. and G. |
| Q-283 | Flush. Sta. | 27′ | 447′ | ..... | ..... | 123′ (?) | 123′ | 273′ | 329′ | 335′ | 420′ | Elv. Cret. & rewkd. P. J. |
| Q-37 | 185-73 Av. | 72′ | 141′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Rewkd. P. G. under Wis. |
| Q-280 | Bayside Sta. | 8′ | 440′ | (?) | (?) | 137′ | 185′ | 272′ | (?) | 292′ (?) | 392′ | Elv. Cret. mxed. flded Jam. & G. |
| Q-280 | Bayside Sta. | 9′ | 430′ | (?) | 139′ (?) | (?) | 211′ | 238′ | (?) | 342′ (?) | 421′ (?) | Elv. Cret. mxd rewkd Jam. & Gard. |
| Q-280 | Bayside Sta. | 10′ | 404′ | (?) | 152′ | 168′ | (?) | 225′ (?) | ..... | 338′ | 389′ (?) | Elv. Cret. mxd rewkd Jam. & Gard. |
| Q-280 | Bayside Sta. | 9′ | 367′ | 67′ (?) | 112′ | 142′ | ..... | 269′ (?) | ..... | 318′ (?) | ..... | Elv. Cret, mxd flded Jam. & Gard. |
| Q-280 | Bayside Sta. | 9′ | 391′ | (?) | 121′ (?) | 173′ | ..... | 266′ (?) | 306′ (?) | 313′ | (?) | Elv. Cret. mxd rewkd Jam. & Gard. |
| Q-280 | Bayside Sta. | 9′ | 399′ | 103′ | 117′ | 144′ | ..... | 258′ | 312′ (?) | 332′ | 389′ | Elv. Cret. mxd rewkd Jam. & Gard. Wis. under marsh. |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q-280 | Bayside Sta. | 10′ | 400′ | (?) | ..... | 130′ (?) | 245′ (?) | (?) | 292′ (?) | 308′ | ..... | Elv. Cret. mxd flded Jam. & Gard. |
| Q-280 | Bayside Sta. | 8′ | 390′ | 86′ | (?) | 182′ | ..... | 249′ | 335′ (?) | 350′ | ..... | Elv. Cret. mxd flded Jam. & Cret. |
| Q-280 | Bayside Sta. | 10′ | 379′ | 72′ | 108′ | 169′ (?) | (?) | 238′ (?) | | 319′ | ..... | Elv. Cret. mxd rewkd Jam. & Gard. Wis. under marsh. |
| Q-280 | Bayside Sta. | 10′ | 298′ | (?) | 132′ (?) | 158′ (?) | 258′ | 264′ | ..... | ..... | ..... | Elv. Cret. mxd flded Jam. & Gard. |
| Q-280 | Bayside Sta. | 9′ | 391′ | 80′ | 99′ (?) | 152′ | 242′ | 266′ | ..... | 332′ | ..... | Elv. Cret. mxd rewkd Jam. & Gard. Wis. under marsh. |
| Q-280 | Bayside Sta. | 9′ | 335′ | 92′ | 142′ | 167′ (?) | 226′ | 251′ | ..... | 291′ (?) | ..... | Elv. Cret. mxd flded Jam. & Gard. |
| Q-280 | Bay. Cal. t. w. | 11′ | 189′ | (?) | 110′ | 156′ | (?) | ..... | ..... | ..... | ..... | Elv. Cret. mxd flded Jam. & Card. |
| Q-275 | Douglaston | 5′ | 456′ | 80′ (?) | 125′ | 162′ | 231′ (?) | 355′ (?) | 365′ (?) | 385′ | 451′ (?) | Elv. Cret. mxd rewkd Jam. |
| Q-278 | Douglaston | 16′ | 536′ | 59′ | 88′ | 196′ | ..... | 357′ | 387′ (?) | 411′ | 520′ (?) | Elv. Cret. mxd rewkd Jam. & Gard. |
| Q-277 | Douglaston | 16′ | 152′ | (?) | 88′ (?) | ..... | ..... | ..... | ..... | ..... | ..... | Elv. Ja. mxd rewkd Gard. |
| Q-276 | Douglaston | 24′ | 531′ | (?) | 104′ | 192′ | ..... | 340′ (?) | ..... | 411′ | 507′ (?) | Elv. Cret. mxd rewkd Jam. & Gard. |
| Q-116 | Com. Bd. @G. C. | 235′ (?) | 288′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All rewkd and moraine material. |
| Q-23 | Met.-Flush | 25′ | 59′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Reworked P. G. |
| Q-22 | 58-Flush | 44′ | 94′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Reworked P. G. |
| Q-27 | 92 nr. Corona | 57′ | 301′ | ..... | ..... | 106′ | ..... | ..... | 106′ | 187′ | 244′ (?) | Reworked above Cret. |
| Q-202 | 80-20 Cald | 95′ | 115′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-243 | 62 Dr.-Wdhvn | 70′ | 94′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All Wisconsin. |
| Q-25 | 112 Cypress | 69′ | 132′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-51 | Cyp. nr. Mad | 70′ | 175′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-47 | Wyc.-Decat | 76′ | 131′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-48 | Coop.-LIRR | 65′ | 130′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-52 | 71-Frsh P. Rd | 80′ | 150′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-172 | Cyp. Av.-Cyp. R. | 111′ (?) | 204′ | 93′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-29 | 83-Dry Harb | 77′ | 156′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-341 | Forest Pk | 100′ | 245′ | 145′ (?) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |
| Q-30 | LIRR-Glen | 63′ | 528′ | 91′ | 141′ | 221′ | ..... | ..... | 337′ | 367′ | 465′ | All rewkd Cret. mxd Jam. Outwash P. G. under moraine. |
| Qx-62 | Hrse. Cr.-G. C. | 10′ | 70′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-62 | 63-C.C. Pky | 2′ | 90′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-62 | Hrse. Cr.-G. C. | 2′ | 84′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-64 | 130th-64 Rd | 2′ | 70′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-63 | 64 Rd.-G. C. P | 2′ | 91′ | 86′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-63 | 65 Rd.-G. C. P | 2′ | 91′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-66 | 67 Rd.-G. C. P | 1′ | 83′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All marsh. |
| Q-270 | No. 3 Sta | 10′ (?) | 416′ | ..... | ..... | ..... | ..... | ..... | ..... | 406′ (?) | ..... | Bottom Lds. app. 406′. |
| Q-270 | 68 Rd.-Fl. Cr. | 1′ | 70′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | U. P. | Mag. | L. P. | Lds. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q-270B......... | No. 4 Sta........... | 15′ | 435′ | (?) | (?) | 135′ (?) | ..... | ..... | ..... | 355′ | 414′ | Wis. under marsh Cret. elv. G. & J. mixed. |
| Qx-67........... | 124-69 Rd.......... | 1′ | 91′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | All disturbed P. G. |
| Q-32............ | 69 Rd.-Fl. Cr....... | 15′ | 290′ | ..... | ..... | ..... | ..... | ..... | ..... | 275′ (?) | ..... | Disturbed P. G. under marsh. |
| Q-270C......... | Veatch No. 151..... | 10′ (?) | 190′ | 80′ | ..... | 190′ (?) | ..... | ..... | ..... | ..... | ..... | Elv. Cret. mxd. Jam. |
| Qx-68........... | 130-71 Rd.......... | 0′ | 89′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Disturbed P. G. under marsh. |
| Qx-68........... | 130-71 Rd.......... | 1′ | 75′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-68........... | 72-G. C. Pky....... | 7′ | 60′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-69........... | 130-72 Dr.......... | 1′ | 91′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-69........... | 124-72 Rd.......... | 0′ | 114′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Qx-69........... | 124-72 Rd.......... | 0′ | 104′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Wis. under marsh. |
| Q-272........... | For. Hill St......... | 8′ | 495′ | 87′ | ..... | 87′ | 233′ (?) | ..... | 310′ (?) | 318′ | 462′ | Elv. Cret. in touch Wisconsin. |
| Q-272........... | For. Hill St......... | 5′ | 630′ | (?) | (?) | 125′ | ..... | ..... | ..... | 325′ | 445′ (?) | Elv. Cret. in touch P. G. |
| Q-271........... | For. Hill St......... | 18′ | 488′ | 85′ (?) | (?) | 131′ | 255′ (?) | 290′ (?) | ..... | 358′ | ..... | Elv. Cret. in touch mxd J. & G. rewkd P. G. |
| Q-213........... | 81-01 Leff.......... | 112′ | 12′ | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Outwash P. G. under moraine. |

## SECTION III—QUEENS COUNTY

This section, like Section III in Kings, is a province westward of the Sound River Valley and its outstanding feature is the absence of all economic water-bearing sediments, except Post-Gardiners. Moreover, it is distinctive in receiving its fresh water supply practically entirely from rainfall upon the surface north of the Queens Moraine. Reworking of Post-Cretaceous sediments by Ice drag during the advance of the Queens Moraine is evident everywhere in Section III. Fresh water development is variable, depending upon the depth to which Post-Gardiners sediments may extend below sea level. Intermingling of Cretaceous with Jameco and even Post-Gardiners may be found almost indiscriminately.

Bed rock in the form of irregular knobs rises above sea level along the East River in parts of both Long Island City and Astoria and plunges generally southeastward to a maximum depth of approximately El. —250 at the head of Flushing Bay. Along the arbitrary southeastern boundary line bed rock ranges between El. —225 and El. —250. There are several shallow rock trenches in Long Island City and Astoria which apparently represent former tributaries of the East River, as well as the rock embayment at the head of Maspeth and Newtown Creeks, previously discussed.

Neither Lloyds nor glacial Jameco gravels occur anywhere in this section, except for possible irregular "feathering" projections along its arbitrary boundary line. In the southeast corner, below the Queens Moraine, the sediments between bed rock and the top of the Gardiners are predominantly fine sands and clays forming an impermeable Jameco seal against salt intrusion from the tributaries of Newtown Creek.

### Section III—Queens County

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| Qx-5 | Tri-Br | 9′ | 72′ | .... | .... | .... | 50′ | Reworked Cret. |
| Qx-6 | 22 Dr.-Sh. Bd | 43′ | 46′ | (?) | .... | .... | +8′ | Reworked P. G. |
| Qx-8 | 19-23 Rd | 45′ | 74′ | (?) | .... | .... | 24′ | Reworked P. G. |
| Q-1 | Barc-Tri. Br | 33′ | 64′ | (?) | .... | .... | 17′ | Reworked P. G. |
| Qx-9 | 19-24 Dr | 37′ | 82′ | (?) | .... | .... | 40′ | Reworked P. G. |
| Qx-10 | 23-25 Ave | 22′ | 50′ | (?) | .... | .... | 23′ | Reworked P. G. |
| Q-236 | 3rd-26 Ave | 6′ | 30′ | (?) | .... | .... | 20′ | Reworked P. G. |
| Q-6 | 4th-26 Ave | 15′ | 58′ | (?) | .... | .... | 41′ | Reworked P. G. |
| Qx-11 | 3-Ast. Bvd | 5′ | 50′ | (?) | .... | .... | 42′ | Reworked P. G. |
| Qx-12 | Ver. Bd.-31 Av | 6′ | 57′ | (?) | .... | .... | 42′ | Reworked P. G. |
| Qx-13 | Bway-Ver. Bd | 5′ | 31′ | (?) | .... | .... | 22′ | Reworked P. G. |
| Qx-14 | 21-37th | 13′ | 68′ | .... | .... | .... | .... | Reworked Cret. and P. G. |
| Qx-15 | 21-35th | 0′ | 73′ | (?) | .... | .... | .... | Reworked P. G. |
| Qx-16 | Bway-29th | 35′ | 90′ | (?) | .... | .... | .... | Reworked P. G. |
| Qx-19 | PHL-Q. Br | 6′ | 45′ | .... | .... | .... | 29′ (?) | Reworked Cret. and P. G. |
| Qx-19 | PHL-Q. Br | 6′ | 40′ | .... | .... | .... | .... | Reworked Cret. and P. G. |
| Qx-21 | E. Riv.-44 Rd | 0′ | 66′ | (?) | .... | .... | 56′ | Reworked P. G. |
| Qx-21 | E. Riv.-44 Rd | 0′ | 29′ | (?) | .... | .... | 19′ | Reworked P. G. |
| Qx-21 | In River | 0′ | 89′ | (?) | .... | .... | .... | Reworked P. G. |
| Qx-22 | 44 Dr-Ver. Bd | 7′ | 53′ | (?) | .... | .... | 41′ | Reworked P. G. |
| Q-16 | 23-nr. 43rd | 14′ | 40′ | (?) | .... | .... | 26′ (?) | Reworked P. G. |
| Qx-23 | 29-Brd. Plaz | 17′ | 40′ | (?) | .... | .... | 23′ (?) | Reworked P. G. |

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| Qx-22A.... | 44 Dr-Hunter..... | 13′ | 36′ | (?) | .... | .... | .... | Reworked P. G. |
| Q-173...... | 21st-46th......... | 12′ | 67′ | (?) | .... | .... | 40′ | Reworked P. G. |
| Q-173...... | 21st-46th......... | 13′ | 68′ | (?) | .... | .... | .... | Reworked P. G. |
| Qx-27...... | 21-47th.......... | 9′ | 70′ | (?) | .... | .... | 48′ | Reworked P. G. |
| Qx-26...... | 49-Jack. Ave..... | 17′ | 69′ | (?) | .... | .... | 42′ | Reworked P. G. |
| Qx-25...... | 5th-Borden....... | 7′ | 66′ | 47′ | .... | .... | 49′ | Reworked P. G. |
| Qx-25A.... | 53 @E. River..... | 2′ | 99′ | (?) | .... | .... | 47′ | Reworked P. G. |
| Qx-25A.... | 53 @E. Piver..... | 0′ | 83′ | (?) | .... | .... | 83′ (?) | Reworked P. G. |
| Qx-25A.... | 53-in Riv........ | 0′ | 109′ | (?) | .... | .... | 109′ (?) | Reworked P. G. |
| Qx-25A.... | 2nd @Borden..... | 4′ | 72′ | (?) | .... | .... | 45′ | Reworked P. G. |
| Qx-25A.... | E. Riv.-Bord..... | 0′ | 52′ | (?) | .... | .... | 38′ | Reworked P. G. |
| Qx-25A.... | E. Riv.-Bord..... | 0′ | 66′ | (?) | .... | .... | 64′ | Reworked P. G. |
| Qx-25A.... | In River......... | 0′ | 122′ | (?) | .... | .... | .... | Reworked P. J. |
| Qx-25A.... | 5th @Borden..... | 7′ | 64′ | (?) | .... | .... | 47′ | Reworked P. G. |
| Q-163...... | 21-51st.......... | 6′ | 51′ | (?) | .... | .... | 24′ | Reworked P. G. |
| Q-163...... | 21-New. Cr....... | 7′ | 74′ | (?) | .... | .... | 67′ (?) | Reworked P. G. |
| Q-117...... | Hunt.-Skill....... | 1′ | 41′ | (?) | .... | .... | 35′ | Reworked P. G. |
| Q-117...... | Crane-LIRR..... | 2′ | 67′ | (?) | .... | .... | 60′ | Reworked P. G. |
| Q-171...... | Skill.-Q. Bd...... | 46′ | 500′ | (?) | .... | .... | 41′ | Reworked P. G. |
| Q-181...... | Jack.-Br. Pl...... | 19′ | 48′ | (?) | .... | .... | 29′ | Reworked P. G. |
| Q-13....... | Jack. Hon'll...... | 20′ (?) | 89′ | (?) | .... | .... | 69′ | Reworked P. G. |
| Q-59....... | Stwy.-35th....... | 43′ | 122′ | (?) | .... | .... | 59′ | Reworked Cret. and P. G. |
| Qx-17...... | Stwy.-Astor...... | 64′ | 126′ | (?) | .... | .... | 41′ | Reworked Cret. and P. G. |
| Qx-7....... | Stwy.-E. Riv..... | 19′ | 95′ | (?) | .... | .... | 56′ | Reworked P. G. |
| Qx-7C..... | In Chanel........ | 0′ | 145′ | 98′ | .... | .... | 116′ | Reworked Cret. and P. G. |
| Qx-18D.... | 48-Bow. Bay..... | 0′ | 143′ | (?) | .... | .... | 106′ | Reworked Cret. and P. G. |
| Qx-18C.... | 48th-19th........ | 8′ | 110′ | (?) | .... | .... | 82′ | Reworked Cret. and P. G. |
| Qx-18B.... | 48th-20th........ | 21′ | 124′ | (?) | .... | .... | 71′ | Reworked Cret. and P. G. |
| Qx-18A.... | Ast.-48th......... | 56′ | 121′ | (?) | .... | .... | 38′ | Reworked P. G. |
| Qx-18...... | 48th-28th........ | 66′ | 128′ | (?) | .... | .... | 42′ | Reworked P. G. |
| Qx-20...... | 48th-Bway....... | 46′ | 121′ | (?) | .... | .... | 54′ | Reworked P. G. |
| Q-125...... | 54th-31st........ | 45′ | 74′ | .... | .... | .... | .... | All Wisconsin. |
| Q-262...... | 71 nr. N. Bd...... | 20′ | 227′ | 98′ | .... | .... | 118′ | Veatch No. 162 Reworked P. G. |
| Q-62....... | Grove-Drey...... | 30′ | 129′ | (?) | .... | .... | 94′ | Reworked Cret. and P. G. |
| Q-263...... | 48th-Dreyer...... | 33′ | 132′ | (?) | .... | .... | 85′ | Veatch No. 99 Reworked Cret. and P. G. |
| Qx-29...... | 39th-43rd........ | 68′ | 147′ | (?) | .... | .... | 77′ | Reworked P. G. |
| Qx-29...... | 39th-43rd........ | 75′ | 159′ | (?) | .... | .... | 64′ | Reworked P. G. |
| Q-57....... | 47-Vandam....... | 21′ | 77′ | (?) | .... | .... | .... | Reworked P. G. |
| Q-122...... | 33rd-48th........ | 45′ | 125′ | (?) | .... | .... | 80′ | Reworked Cret. and P. G. |
| Q-179...... | Grnpt. New. C.... | 0′ | 74′ | (?) | .... | .... | 74′ (?) | Reworked Cret. and P. G. |
| Qx-30...... | 39th-48th........ | 64′ | 165′ | (?) | .... | .... | 81′ | Reworked Cret. and P. G. |
| Qx-30...... | 39th-48th........ | 65′ | 169′ | (?) | .... | .... | 104′ | Reworked P. G. |
| Qx-30...... | 39th-48th........ | 64′ | 172′ | (?) | .... | .... | 91′ | Reworked P. G. |
| Qx-30...... | 39th-48th........ | 64′ | 176′ | (?) | .... | .... | 91′ | Reworked Cret. and P. G. |
| Qx-30...... | 39th-50th........ | 67′ | 222′ | (?) | .... | .... | 110′ | Reworked Cret. and P. G. |
| Qx-35...... | 39-Hunt. Pt...... | 48′ | 175′ | (?) | .... | .... | 114′ | Reworked Cret. and P. G. |
| Qx-40...... | Rev. nr. L. Bd.... | 23′ | 211′ | .... | .... | .... | 171′ | Reworked Cret. in touch Gard. |
| Qx-41...... | Cal. Cem......... | 69′ | 202′ | .... | .... | .... | 111′ | Reworked Cret. and P. J. |
| Qx-41...... | Rev. nr. L. Bvd... | 17′ | 170′ | .... | .... | .... | 133′ | Reworked Cret. in touch Gard. |
| Qx-42...... | 57-L. H. Bvd..... | 28′ | 61′ | (?) | .... | .... | .... | Reworked P. G. |
| Qx-36...... | 42-Borden........ | 64′ | 234′ | .... | .... | .... | 150′ | Reworked Cret. in touch Gard. |
| Qx-43...... | 43-53 Dr......... | 9′ | 80′ | (?) | .... | .... | .... | Reworked P. G. |
| Qx-43...... | Town.-Newt...... | 0′ | 106′ | .... | .... | .... | .... | Reworked P. J. |
| Qx-44...... | Masp.-Newt...... | 8′ | 217′ | (?) | .... | .... | 209′ (?) | Reworked Cret. in touch Gard. |
| Qx-45...... | New. Cr. @Mun.. | 4′ | 208′ | 84′ (?) | .... | (?) | 184′ | Reworked Cret. in touch Gard. |
| Qx-45...... | 49th-57th........ | 3′ | 200′ | (?) | .... | .... | 183′ | Reworked Cret. in touch Gard. |
| Qx-44A.... | 54-Maspeth...... | 5′ | 260′ | 97′ | 131′ | (?) | 207′ | Reworked Cret. in touch Gard. |
| Q-21....... | 59th-56 Dr....... | 24′ | 168′ | (?) | .... | 119′ (?) | 121′ | Reworked Cret. in touch Gard. |
| Q-23....... | Met.-Flush....... | 25′ | 59′ | .... | .... | .... | .... | Reworked P. G. |
| Qx-39B.... | 48th-54 Dr....... | 63′ | 259′ | .... | .... | .... | 176′ | Reworked Cret. in touch Gard. |
| Qx-39A..... | 56th-Borden...... | 28′ | 199′ | (?) | .... | .... | 151′ | Reworked Cret. in touch Gard. |
| Q-267...... | Maur.-Borden.... | 23′ | 160′ | .... | .... | .... | 137′ | Reworked P. J. |
| Qx-39...... | 48th-Borden...... | 89′ | 263′ | .... | .... | .... | 148′ | Reworked Cret. in touch Gard. |
| Qx-38...... | 48th-51 Rd....... | 115′ | 302′ | (?) | .... | .... | 167′ | Reworked Cret. in touch Gard. |
| Qx-37...... | 48th-L. H. Bv.... | 104′ | 243′ | .... | .... | .... | 119′ | Reworked Cret. and P. J. |
| Qx-37...... | 46th-L. H. Bv.... | 101′ | 245′ | .... | .... | .... | 125′ | Reworked Cret. and P. G. |
| Qx-33...... | 48th-50th........ | 98′ | 267′ | (?) | .... | .... | 145′ | Reworked Cret. in touch Gard. |
| Qx-33...... | New Cal. Cem.... | 90′ | 582′ | (?) | .... | .... | 114′ | Reworked Cret. in touch Gard. |
| Qx-32...... | 48th-Qns. Bv..... | 91′ | 228′ | (?) | .... | .... | 122′ | Reworked Cret. in touch Gard. |

| No. | Location | El. | Dph. | P. G. | P. J. | P. C. | Rock | Notes |
|---|---|---|---|---|---|---|---|---|
| Qx-31...... | 48-Skillman...... | 63′ | 147′ | .... | .... | .... | 64′ | Reworked P. G. |
| Q-96....... | 61-Roosevelt..... | 50′ (?) | 65′ | .... | .... | .... | .... | Reworked P. G. |
| Q-206...... | 62-Roosevelt..... | 48′ (?) | 230′ | (?) | .... | .... | .... | Reworked Cret. in touch Gard. |
| Q-112...... | 64th-34th........ | 31′ | 75′ | .... | .... | .... | .... | All Wisconsin. |
| Q-293A.... | 73-Roosevelt..... | 55′ | 275′ | (?) | (?) | 97′ (?) | 195′ | Reworked P. C. mixed with Jam. Reworked P. G. |
| Q-293...... | 82-Roosevelt..... | 52′ | 80′ | (?) | .... | .... | .... | Reworked P. G. |
| Q-64....... | 82-45th.......... | 35′ | 112′ | .... | .... | .... | .... | Reworked P. G. Gard. elevated. |
| Q-64....... | 82-45th.......... | 35′ | 131′ | (?) | .... | .... | .... | Reworked P. J. Jam. elevated. |
| Q-64....... | 82-45th.......... | 40′ | 155′ | (?) | .... | .... | .... | Reworked P. G. Gard. elevated. |
| Q-268...... | Bway.@Cornish... | 15′ | 297′ | .... | .... | .... | 278′ | Reached Lds. (?). |
| Q-27....... | 92-LIRR......... | 57′ | 301′ | (?) | (?) | 106′ | 244′ (?) | Reworked Cret. in touch Gard. |
| Q-187...... | 102-45th Av...... | 40′ | 146′ | 100′ | .... | .... | .... | Reworked P. G. |

## LONG ISLAND GROUND WATER BULLETINS

GW-1 Withdrawal of Ground Water on Long Island, N. Y.
D. G. Thompson and R. M. Leggette, 1936

GW-2 Engineering Report on the Water Supplies of Long Island
Russell Suter, Executive Engineer, Water Power and Control Commission, February 1, 1937

GW-3 Records of Wells in Kings County, N. Y.
U.S.G.S., 1937

GW-4 Records of Wells in Suffolk County, N. Y.
U.S.G.S., 1938

GW-5 Records of Wells in Nassau County, N. Y.
U.S.G.S., 1938

GW-6 Records of Wells in Queens County, N. Y.
U.S.G.S., 1938

GW-7 Report of the Geology and Hydrology of Kings and Queens Counties, Long Island,
J. Homer Sanford, 1938.